UNIVERSITY OF PENNSYLVANIA

INDIVIDUAL PRODUCTION RATING

A STUDY OF MEASUREMENT OF QUANTITY AND QUALITY OF INDIVIDUAL PRODUCTIVE OUTPUT IN TWO TEXTILE OPERATIONS

JOHN CLIFFORD SHOVER

A THESIS

IN ECONOMICS

PRESENTED TO THE FACULTY OF THE GRADUATE SCHOOL IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

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To My Wife

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INTRODUCTION

This research explores the problem of measuring differences in individual output. In spite of the importance of individual production rating in evaluating results of either routine or experimental work in both personnel and production policies, no scientific technique has been developed for its use in industry. This study demonstrates in a concrete and practical way how employee rating can be done scientifically.

The characteristic which makes any management scientific is executive control based upon measurements. Under the old methods of supervision, the manager told his employees to do what he thought was best. As industrial plants grew in size, more and more of the manager's functions and methods fell to the lot of the foreman. Now under the newer methods the bases on which decisions are made are no longer in the foreman's head, but have been placed by the scientific manager in files. Instead of having each foreman depend upon his limited experience or such observations as he can remember, the scientific manager collects records of experiences and on the bases of these records, exercises executive control.

Two principles make scientific management possible. The first is that the results of the various combinations of materials, machinery, processes and circumstances are measurable to a point of usable accuracy. The other principle is that from given conditions and circumstances in certain cases, the results in similar cases can be predicted with a fair degree of dependability.

Recently attempts have been made to apply these two principles of measureability and predictability to the labor factor. Behavioristic psychology makes a considerable claim to the possibility of predicting human action from tests of aptitudes. If the claim is to be verified it must be by objective measurement of the results of human efforts. Speaking before a society of industrial engineers in Philadelphia,

March, 1925, Doctor Lillian M. Gilbreth said that what psychological and fatigue studies need more than anything else are objective criteria regarding human performance. Only a few months before, Doctor W. V. Bingham, Director of Personnel Research Foundation, told the Taylor Society that research studies stand in need of criteria or measures of individual productive output.

"Various phases of employment work such as selection, placement, promotion, and training, are awaiting studies of ways of measuring production of individual employees."

This thesis is devoted to the problem of measuring these differences. It is a matter of objective measurement and so it has been studied as a laboratory experiment. It is also a practical problem, consequently much stress is laid upon reliability of the measurements, but the refinements of the measurements have been carried only to a point of acceptable use in actual practice. The study of measurement is limited to quantity and quality of productive output in two textile operations.

Fortunately five mills opened their doors and their records to this research. Conditions existing in these mills were surveyed, available records examined, and a rating plan developed to fit the job and the conditions. Although the accurate description of conditions and the application of a rating plan are specific, a method or technique has been outlined as it was developed.

This study was started under the direction of Doctor Joseph H. Willits of the Department of Geography and Industry; it was completed under the guidance of Miss Anne Bezanson of the Department of Industrial Research. For helpful criticisms and valuable suggestions, the writer is very greatly indebted to both Miss Bezanson and Doctor Willits. To the various members of the staff of the Department of Geography and Industry is extended appreciation for their stimulating comments and useful criticisms.

Grateful acknowledgment is made to the textile mills which entered into the study. Their helpful attitude and

generous assistance is most deserving of an expression of gratitude.

It would be of interest and value to compare the rating plan as devised and applied in these mills with other individual production rating plans. Such a comparison cannot be made as no detailed description of any other employee production rating plan is available.

The bibliography is general. Without exception the books deal with the subject of individual rating in a general way, or else state the lack of detailed research; the articles are of the same tenor or they give only brief outlines of employee rating in which some consideration is given to the production factor. The dearth of material for comparison indicates the original nature of any careful and extended research in this field.

CHAPTER 1

THE NEED FOR INDIVIDUAL PRODUCTION RATING

The fullness of life is dependent largely upon human factors. No matter how rich the natural resources, the preparation and the operation of machinery to convert the resources into utilities depend upon persons. Thus the problem of how best to utilize labor is one of vast significance. With the struggle for higher wages, with the demand for shorter working hours, with rising standards of living and increasing costs of raw materials, the better utilization of labor becomes a very pressing problem. Improvement of labor output may be attained by reduction to a minimum of stoppages and delays in regular working hours. Increased output can be attained also from improvement and standardization of materials, processes, machinery, methods and working conditions. A third way of improving the utilization of labor is to upgrade the workers to higher standards of individual output.[1] It is with a phase of this third method that this thesis is concerned.

Objective measurements of individual output have not been sufficiently developed. Success in upgrading the worker, getting the right man on the job doing his best, is not easily weighed. Bidding for a slave was an old method of selecting the right man for the job, and the slave owner used a whip when in his opinion the slave was not working hard enough. Interviews, trade tests, pschological tests and medical examinations are some of the methods now used in an effort to get the right man selected and placed on the

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[1] "Industry centers around the worker. This is an age of machine-made products, but still the output of the machines remains dependent upon the worker. This is well demonstrated by the experience of a group of English textile mills with looms that were automatons of perfection . . . . it was found that the efficiency of each loom and the output of the factory depended not so much upon the mechanical perfection of the machines as it did upon the abilities of the workers in charge of the looms." Laird, Donald A. The Psychology of Selecting Men. New York: McGraw-Hill Book Co. 1925. p. 160.

right job. Piece rates, incentive wage plans, training programs, welfare activities and other management devices are used to improve the worker on his job. In spite of the great changes in the character of the management devices used in upgrading the worker, very little attention has been given to the problem of determining what results have been obtained by the use of the devices. Because opinions regarding the value of individual services generally have not been checked against objective measurement, reliable criteria regarding the effectiveness of efforts to upgrade the worker are lacking.[2] This study undertakes to explain and illustrate by example how objective measurements of individual output may be developed in a particular job.

Although personal opinions will continue to have a part in labor management, a large number of underlying causes are tending toward the use of definite ratings based on objective facts. Among these causes are:

a. A demand for large quantities of production,
b. Better organization of markets,
c. Hand to mouth buying,
d. Limited natural resources, and limitations in the supply of labor,
e. The introduction of revised wage plans,
f. The development of standardization,
g. Growing interest in personnel studies,
h. Improvement in cost analysis.

A brief explanation of these causes will indicate how they operate to increase the demand for more accurate personnel measurements.

When America was first settled, the vast acres of land, the huge forests, the great rivers, the resources of the mines, all challenged the newcome to mass production. The task was one of proportions. Gang-plows, tractors, threshing combines, gold rushes, oil plunging, ring spindles, and moving lines of production were speeded up with tremen-

[2]Patterson, Donald G. Methods of Rating Human Qualities. The Annals of the American Academy of Polictical and Social Science. November, 1923. p. 81.

dous energy. To attain high production, the industrialist learned to depend upon production records rather than a foreman's impression or guess.

As the markets have become better organized, it has been growing harder for any one manufacturer to maintain for himself a favorable price differential either of raw materials, of finished products or of labor. Any economies from management developments in one plant have in the same way reacted more forcibly to compel other plants to find and adopt similar or equivalent economies.

Hand-to-mouth buying has helped to bring attention to objective measurements of employee production. Early delivery dates have to be met in order to secure and retain orders, and so manufacturers must have something more definite than impressions regarding production per employee, that they may know what force of employees is needed to meet due dates of delivery. If productive output per man-hour can be increased, it may be possible to enlarge total production without corresponding increases in costs, perhaps even with lower costs per unit.

Coupled with the market factor is the fact that natural resources and the supply of labor are limited. Increasing demands for the limited resources result in higher costs of the raw materials, unless there are improvements in the arts to offset the increasing difficulty of securing greater quantities. The limited supply of labor has a similar tendency; namely, a tendency toward economy or improvement in the use of the supply. This supply is limited by the total population; and immigration restrictions of this country have curtailed the one source of immediate large increase.

One of the management devices in this competitive race for high production at low costs was the introduction of piece rates. It enabled the manager to calculate his costs more accurately, reward the more productive employee and at the same time reduce unit costs. Piece rates also make possible an objective measurement of the productiveness

of employees.[3] Wherever piece rate earnings were tabulated and referred to in case of a change of personnel, a systematic rating had been started. Wherever fines for poor work were introduced, there was a possibility of referring to a record of quality. It was a rough record, one which perhaps showed only the very bad production which the foreman or inspector had been watchful enough to discover. Though incomplete such records made a beginning of quantity and quality measurements. Incentive wage systems gave further impetus to the demand for the accurate rating of employees. These systems enhance earnings of the fast workers and leave the bare earnings of the poorer operators in greater contrast than do the ordinary piece rates or guarantee day rates. The records from piece work or incentive wage plans are tangible, definite, and constructive bases for mathematical comparisons.

In many industrial plants efforts were made toward standardization. Time studies were introduced in an effort to find the best way to do a job and just how much time it should take. Often it was found that the man with the best production record was not always the best worker. By accident he happened to have the kind of reed hook (an instrument used by weavers to draw yarn through certain eyelets) best suited to the job. Perhaps the best worker had only a moderate production record, due to delays and difficulties none of which were his own fault. Standardization had been started in a general way many years before in machinery parts. Now in some plants the scientific manager begins with greater thoroughness to standardize the mechanics of production: machinery, materials, processing, the finished product, and then the working conditions, and the job itself. If finally the standard instructions are followed under stan-

[3] "It seems almost unbelievable that one of the most fundamental principles in the science of management, namely, the recognition of individual aptitudes and differences by means of a piece-work rate, should be so largely neglected in its application to the retention and re-selection of employees." Link, H. C. Employment Psychology. New York: The MacMillan Co., p. 310.

dard conditions, it is easier to find the relationship between the output of the employee and his value to the concern.

Along with other scientific studies of industrial matters were those devoted to personnel. These studies brought to light the facts concerning time irregularities of performance by labor. Labor turnover studies emphasize the losses from lessened productivity and wastes from unnecessary costs in hiring, training, supervision, accidents, and spoilage. Absentee study expressed the actual number of man-days supplied in comparison with the number for which the expenses of equipping and running the mill were incurred. But to get the utmost significance or value from these studies, it is found necessary to consider the individual's total production in any period with reference to the average of all operators in the department and here again was a need for individual production records of greater accuracy. Related to these studies are investigations and experiments with welfare work, psychological testing, working conditions and appliances, training, and job procedures. Concrete evidence is needed to verify the advantages or disadvantages of each experiment. Valid criteria are found in individual production records. How can it be known what temperature is best for working conditions in a given job unless there is a measurement of output? A psychological test may conclude that certain persons of a group have greater aptitudes for the work of weaving. But the validity of any selective test depends upon the validity of the standards with which it is checked.

On the more urgent side of the question, we find that cost accounting has a very significant contribution to make to employee rating. Demonstrations of financial advantages are not so lightly ignored as are the less tangible results of the other factors. The following sample of cost analysis is suggestive of the situation in many plants.

In a small factory of 400 employees at an average weekly wage of 25 dollars, working 48 weeks in the year,[4] the annual totals of expenses would be approximately as follows:

Total pay roll,, direct labor	$480,000
Total other expenses, not including materials[5]	720,000
Total cost for processing 100 units	$1,200,000

Now suppose that the employees, all on piece rate, were to increase production 15%. The overhead would be increased by only a small item for power, trucking, packing, etc. Building and equipment in better use could take care of the increased production. Making some allowance for the additional cost mentioned, suppose the indirect costs are increased one-fifth as much as the wage costs. Let us assume the cost of studies, developmental work, incentives, etc., is one fifth of the increase in wage costs. Our figures would then be as follows:

Payroll	$480,000	
Plus 15%	72,000	$552,000
Total other expenses not including materials	720,000	
Additional overhead for 15% increase in production	14,400	
Production studies $8,200 developmental work 6,200	14,400	748,800
Total cost for processing 115 units		$1,300,800

[4] Average weekly earnings in the Cotton Goods industries of Pennsylvania for week ending December 15, 1928 were $24.99. Labor and Industry of Commonwealth of Pennsylvania, Vol. XVI., Number 2, February, 1929, p. 46.

[5] The distribution of expenses is based on figures taken from the 1920 Abstract of the 14th Census of United States, p. 1178. In the Cotton Goods industry, total wages not including salaries of clerks and officers amounted to $355,474,937 for the year 1919. The value of the products less the cost of materials, i. e. the value added by manufacture, was $847,486,596. According to this, the labor costs for the industry are 42% of the value product. The corresponding figures for 1925 are found in U. S. Census of Manufactures (1925) page 223. Total wages were $353,882,870 and the value added by manufacture was $637,215,173, wages constituting 56% of the value product. The labor costs above are estimated roughly at 40% of the total value added by manufacture.

On the basis of unit costs under the old conditions, the 115 units would cost $1,380,000, whereas the new cost is only $1,300,800. This makes a saving of $79,200 on the cost of goods, or 5.74% of the original labor and overhead costs. The additional 79,000 dollars of profit on the little factory would appeal to the manager as a good reason for improving labor efficiency. This is especially true when in certain periods, the margin of profit in business is rather small.

Cost analysis, however, presents certain demands in order that its findings may be validated. Unless the labor factor is held constant or is reckoned accurately under all the different conditions, the financial outcome cannot be estimated accurately. Effects of changes in manufacture do not lend themselves to exact calculations unless the factors entering into the process are properly reckoned. So it is quite important to have the facts regarding the labor factor as complete and as accurate as possible.

It is profitable for the enterpriser to know just what amount of labor he can best use in his undertaking, past which point there would be a decreased percentage of profit on the investment. If in order to hold the organization together or to hold his trade, the employer must use extreme measures, he must know up to what final limit he can possibly use the labor factor without incurring loss greater than would be caused by being compelled to rebuild his labor force or regain his trade.

Through cost analysis, the employer becomes convinced that there is an economic necessity for correcting the technique of improving or removing the less efficient employees. Since the foreman is in direct charge of the employees, why not make him responsible for the upgrading of workers? There are many reasons why this responsibility cannot be left to the foreman. In the first place, the foreman may not know just what are the weaknesses of his department; and in the second place, the foreman is not in a very satisfactory position to make careful evaluation of all the factors affect-

ing lafor personnel. These difficulties are discussed by Scott and Clothier[6] under the following heads:

a. The foreman is pushed to get work out. The responsibility for getting out production is laid so directly upon the shoulders of the foreman that he does not have time to evaluate carefully all of the elements entering into the efficiency of the employees in his department.

b. A foreman has some difficulty in thinking specifically of any quality of an employee separate from the other qualities of the employee. If rating is being made on quantity, the foreman may not be able to keep out of his mind the fact that John Johnson, who is a fast worker, spoiled a whole set of work two days ago.

c. Spectacular or unusual incidents prejudice the foreman.

d. The foreman is influenced by his personal likes and dislikes.

e. What may be called first-class by one foreman, might not be called first-class by another. One may lay stress on neatness while another may lay stress on speed of movement or staying close to the machine.

From the time that employment began, employee rating has been done, and in the nature of the case always will be done. The question is how it shall be done. Many factors seem to call for a more accurate evaluation of the services of employees in their respective positions than has usually been made in the past. In order that the evaluation may be properly made, it is necessary that the conditions be studied carefully with a view to standardization. There are certain fundamental reasons why the foreman cannot handle the task by himself, and this leaves employee production rating as a management problem. Individual production rating greatly affects costs. To the employer, employee, and the consumer, a plan which helps much in the solution of this problem is of prime importance.

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[6] Personnel Management, Chicago: A. W. Shaw & Co. 1923. p. 199.

CHAPTER II

TYPES OF RATING PLANS

It has been noted that employee rating of the past has usually been based upon personal opinions and that lately many efforts and experiments have been made to revise methods and bases of ratings. A great impetus to this experimentation was occasioned by the tremendous demands for placement service during the war. The thousands of men in the camps had to be sorted into mechanics, cooks, gunners, chauffeurs, secretaries and other occupational groups such as were needed in army and navy service. There was also the problem of selecting the right men for training to carry on special functions such as that of officers, aviators, and observers. Both the nature and the extent of the problem called for more than usual treatment.

Three special methods of selection were used in the exigencies of the war placement service. Trade tests were quickly introduced, improved in character and technique, and used on a large scale to a splendid advantage. Psychological tests, both of general intelligence and of aptitudes, were employed very extensively and were of considerable value for the purposes used. The third method was a form of personal opinion rating, in which a definite system or procedure was followed. Instead of classifying persons in a general way, specific qualities defined in objective terms were rated one at a time for a number of men, by an officer. The rating given each quality was usually made on a five point basis, five being the highest degree. With the careful attention and systematic way of expressing personal opinions in these man-to-man judgment ratings, considerable improvement was made over the casual way of exercising impressions.

At the close of the war, many industrial men went back to their personnel problems with some knowledge and in-

terest in the placement methods used by the government. The psychologists were eager to continue their experiments in industrial plants. All three types of rating, man-to-man judgment rating plans, the trade tests, and the psychological tests were introduced into many industrial organizations. The results were not entirely satisfactory as the rating and testing scores seemed to be at great variance with the opinions of the foremen and with such production records as were noted. The discrepancies between rating scores, foreman's opinions and production records made the managers wonder which was right.[1] Meantime the improvements in management and the improvements mentioned in Chapter I together with interest in the subject kept the problem of employee rating before management.

Since the purpose of industry is production, that is, to convert utilities, it would seem that the essential value of a method of selecting employees for placement would be found in how directly it reflected itself in individual productive output. It would presumably follow that the most important factor regarding an employee in a regular production department would be the quantity and quality of productive output per man-hour and it is our purpose to study individual production rating from this standpoint.[2]

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[1] "The relative unreliability of ratings and rankings are stressed by practically all who write on the subject, but in the vast majority of experiments on the selection of workers reported in the literature these are the only criteria used." Viteles, Morris S. "Standards of Accomplishments: Criteria of Vocational Selection." Journal of Personnel Research, Vol. 4, April 1926. pp. 483-486. c.f. also Bregnan, E. O. "A Scientific Plan" in System, Yol. 41, p. 696. January 1922.

[2] It should be thoroughly understood that the rating of operators on quantity and quality of productive output per man-hour, is not a complete evaluation of the individual's service to a plant. In fact, it is not even a complete individual production rating. For example, the employee should be rated as to regularity of production as shown in the attendance record. It would also be useful to rate the employee in terms of total production as indicated in the employee's total length of service. It is important, likewise, to see how long it took the employee to learn his job, so tnat the learning cost of the employee may be estimated. Beside these factors there are others affecting the employee's value to the concern such as loyalty, cheerfulness, orginality and ability to teach. The attitude of the employee in difficult situations may be of great encouragement to other employees in their work. Cheerfulness may have a similar

In a descriptive way individual production rating may be defined as appraising and ranking the operators of a department with reference to their respective output, proper allowance being made for the attending conditions or circumstances. Our interest is not in how nature and training have endowed the individual for performing the job, but in how well the individual is doing the job.[3]

Before attempting to make the individual production rating, it is well to have in mind the different ways in which the appraisal or ranking may be done. It will indicate better how the problem may be approached and will suggest in what directions one may go to arrive at the appraisal.

The various individual production rating plans may be grouped in three general TYPES which we choose to designate as Absolute, Relative, and Standard.[4]

(Footnote continued)
effect. Originality may express itself in suggestions which an employee offers regarding mill problems. Some firms keep notations on the personal record cards of suggestions offered by the employee and adopted by the management. Ability to teach others is not always found in the fastest, or in the most careful operator. If teaching ability is found in an operator whose production is very ordinary, the factor is important enough to merit a very substantial increase in the rank or rating of the individual. No doubt there are many other factors to be considered, in a complete rating plan of employees.

[3] "An enormous amount of ingenuity and toil has been wasted in devising various psychological tests and other predictive measures of aptitude or accomplishment, and in trying out these measures at considerable expense of time and money on large numbers of employees—operatives, clerks, or sales people—only to discover after all the tabulations of results have been made, that the criteria against which the validity of the tests had to be checked were unreliable. Ratings given by teachers, supervisors or fellow-workmen are notoriously and disappointingly variable and unreliable even though the most improved forms or graphic rating scale are used and the rating is conscientiously and painstakingly done. Ratings are less objective than the other criteria which have been mentioned. They should be used as criteria only when absolutely necessary or as a last resort." Bingham, W. V., Director, Personnel Research Federation. "What Industrial Psychology Asks of Management", Bulletin of the Taylor Society. Vol. IX. Dec. 1924. p. 243.

[4] There is no standard terminology for features or phases of employee production rating. A standard procedure has not been developed as yet. No books on the subject have been published. A few magazine articles show that some plants are endeavoring to develop individual production rating plans. Remarks in conven-

Absolute Rating compares the output of the operator with total possible output if there were no stoppages of the machine for any cause whatever during the entire working period. No allowance is made for personal time, for the removal of the finished product, for securing material, for machine care, nor for any other delays incidental to the work. An example of such a type is that in which a weaver is rated according to his output in comparison with what would have been his production if he had kept his looms running from the beginning of the warp to the end without a single stop during working hours. It is of course, quite impossible for any person to attain a 100% production under Absolute Rating.

Relative Rating is the comparison of the individual production records of all of the employees engaged in similar work, the comparison being made in the same units for all. Thus weavers might be rated as to quantity by comparing the total yardage of similar cloth woven under similar circumstances by each in a given period of time.

Standard Rating, as the name indicates, compares the output of the operator with a given standard. This kind of rating would be readily applied in metal working plants where the following conditions prevail. The feed and speed of metal cutting machines are figured for the kind of job which the operator will have on his machine. The handling time is carefully figured and allowance for personal time is added to the machine and handling time. The operator's output is then compared with the standard time. Under such conditions it is usual for good operators to make the 100% standard.

There are certain advantages and disadvantages in each kind of rating. Absolute Rating shows the discrepancy be-

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(Footnote continued)
tions and sentences in various books or papers indicate that many plants are beginning to lay more stress on individual production records. With no highway of accepted terminology and few guideposts of procedure, there is warrant for a general view of the problem, a particularization of the research and for a description of the landmarks in the part of the field covered.

tween the theoretical and the actual production, indicating in one general figure the amount of lost machine time in the department, whether the losses be due to handling time, machine trouble, or idleness of the operator. It does not make any division or distribution of the lost machine time. It merely shows how much necessity exists for further study of the things which retard porduction. Relative Rating does not show any lost machine time. It only shows the highest individual production that has actually been accomplished, the lowest production, and all of the grades in between, from the lowest to the highest. Relative Rating is merely a comparison of what the operators actually did without stating what accomplishments are reasonable or possible. It does not define a standard but gives the actual average of the group without indicating what the production should be. Standard Rating makes allowances for handling time and for personal needs. Besides the delays figured in the standard, it therefore shows the amount of lost time which is due to factors not counted or allowed for in the standard. As conditions change after a standard time has once been set, it is quite necessary to make the corresponding changes in the standard, for the results under Standard Rating will be vitiated or at least be made incomparable with those of previous periods. Conditions with their corresponding allowances must always be kept in mind when a Standard Rating is being used.

Circumstances determine the best type of rating to use. Relative Rating may very properly serve as the initial plan where standards have not been determined, or where many small details in conditions would involve cumbersome reports and undesirable clerical work. It is a natural approach to the production problem from the foreman's point of view, as it merely states and compares actual individual performance. The foreman often does not know what is the actual performance of his department, as he may have no way of combining the various kinds of production into a single total. As soon as a foreman has the habit of correctly analyzing the productive performance of the em-

ployees in his department, he begins to inquire what the performance should or could be. He wants to know the theoretically perfect production. Comparing an operator's production with this would be Absolute Rating. How nearly an operator can really attain that mark is the next inquiry which leads to Standard Rating. All three types of rating come into consideration but ultimately a standard is sought. Superintendents, foremen and employees consider what really was done in comparison with their standard. From time to time the standards are reviewed to see how much closer they can be brought to the mark of absolute perfection. Which type of rating plan may be adopted at a given time will depend on such factors as simplicity of units of production, possibility of measuring individual output, wage cost per unit, cost of machinery and equipment involved, length of time required for the job, the ease with which conditions may be standardized, and how long they remain constant. However, Standard Rating is the logical type to be used ultimately.

CHAPTER III

THE INDUSTRIAL SETTING IN WHICH AN APPLICATION OF INDIVIDUAL PRODUCTION RATING IS STUDIED

A specific investigation and application of a rating plan will be more illuminating than would be a statement of the essential steps in developing a rating plan. It will make little difference which industry or operation is chosen for study if the conditions and difficulties be representative and if the general method be applied in a typical way. Let us first analyze the environmental conditions attending a job and all that the job involves. By classifying the data used and outlining the steps followed, a technique will be established and illustrated.

Five textile mills opened their doors to the study of production rating. They have cooperated in securing pertinent details and in supplying information. The textile industry is a splendid field for this study as this industry ranks highest of all so-called manufacturing and mechanical industries in number of employees engaged in it.[1] The field will also be interesting because it is thought that far less standardization has been attempted therein than in many other fields, thus presenting a large share of the difficulties to be encountered in the employee rating project.

Winding and weaving, two of the commonest of textile operations, have been chosen for observation. Winding is as essential process in the manufacture of silk, wool, cotton or rayon (artificial silk) yarn; furthermore, winding is required in the making of textile fabrics whether by weaving or knitting. Weaving is a universal operation in cloth-making although it is not the only method of making a fabric. Since there are nearly two miles of yarn in a

[1] United States Census. Vol. VIII. Occupations. p. 146.

square yard of lightweight dress fabric, the length of yarn used in a mill in a day is astounding.[2] To avoid tangles, breaks, or other delays and damage, and to accomplish with the yarn what the operation calls for, the material must be wound into convenient balls, warps, beams, spools, hanks, cops, bobbins, coils, or cones.

For the sake of clarity, concreteness and thoroughness, this study is confined chiefly to a certain winding operation. Chapter VI is devoted to rating weavers. By limiting the study of winding and weaving, it obviates involved descriptions of many different kinds of machinery and operations and lets the method stand out. The operation of cotton winding which is chosen, exhibits the usual obstacles to applying an individual production rating system by its resistance to standardization because of the many variables in the job, in the materials, and in the machinery. The combined records of the winding mills give a sufficient number of operators, about four hundred in all, to admit of statistical grouping and treatment.

Before attacking the main problem of finding a convenient and correct measure of output and comparing the production of the different operators for the purpose of rating them, it is necessary first to get a general view of the employment conditions and the policies in these mills; then, to see how a winding department is handled; and third, carefully to observe how the winding job is performed.

PERSONNEL POLICIES

As in all industries, there was a time when foremen did their own hiring and firing in these mills. In some cases the foremen even purchased their own departmental supplies. Like a manager of a small business, he determined very largely the employment policies of his department, al-

[2] The length of yarn in a yard of fabric depends on many factors such as kinds of goods, size of yarn and the design or pattern. A fine gingham might be made with sixty picks per inch, making 60x36 or 2160 yards of weft per square yard of cloth. 1200 ends in the warp would add 1200 yard of yarn, making a total of 3360 yards or 1.9 miles.

though occasionally individual cases escaped his control and reached the superintendent or general manager. The wages were low and the hours long.

Since the executives are concerned primarily with the problem of production, it has been found very helpful to transfer much of the personnel work to a centralized personnel department. It is now the practice in these mills for all preliminary interviews of applicants to be handled by the employment department. The applicants are placed on the job only on requisition by the foreman. A foreman may reject any of the applicants suggested by the employment department, or in turn the employment department for good reason may reject persons sent in by the foreman for employment.

Formerly, if an employee was good in a department there was very little chance of getting a job in any other department as his foreman would not like to lose the services of the employee. Under present arrangements an employee who is doing satisfactory work stands a much better chance of transfer when he wishes it. Grievances are given more consideration than formerly. Years ago the employee took a chance when he made a complaint about working conditions or working methods. Now the foreman is ready to hear complaints or suggestions, and in any mill where there is an employment director, he is always ready to investigate grievances or requests.

Not only have these general matters regarding employment been put on a much sounder basis, but many service features have been added which look toward the convenience and comfort of the employees. Drinking water is convenient in all the departments. The work rooms are kept clean and light. First-aid kits are at hand, and two mills have dispensary nurses. Operators who wish to see a doctor or dentist are excused from their work for that purpose. All of these mills have connections with some hospital to which they send emergency cases. Considerable medical aid is furnished free to the employees who are in special need of assistance. On the whole, very much more is done for these

employees than merely to provide for their safety and comfort. Conveniences and service features are extended not in a paternalistic way but in such a manner as to be conducive to a very democratic attitude among all the employees.

THE WINDING DEPARTMENT

Only female operators are employed as winders. There is a three months learning period with a pay increase at the end of each month. It is customary for some experienced operator to show the learner what to do, teach her how to tie the weaver's knot, and how to perform the winding job. The learner generally spends a day or two in a small room near the winding room, where there is less distraction than in the large winding room with its busy group of workers. After a few days, she is given a place at some machine with an experienced operator, whom she tries to assist. The operator gives the novice the instruction and training with supervision by the foreman.

After the three months period, the learner is kept on the day rate of pay until a winding machine is available for her, where she may go on piece work. During the last month of the learning period she has an opportunity for piece work on days when some other operator is absent. If a machine is available any time during the last month, the learner is placed on it, with the understanding that if her piece earnings exceed the high day rate, she may take the piece rate rather than the day rate. In each mill the basis of pay is poundage. As it takes much longer to wind a pound of a fine count of yarn than a pound of a coarse count, the rates vary according to the size of the yarn.

The winder asks for new materials whenever she has nearly completed the work on her machine. She takes her operator's card to the assignment clerk of the department. On the way back to her machine she picks up a stack of paper cones that she will need for the next job. The assignment clerk takes these cards in order, notes what kind of work the operator has been running, and then makes a new assignment from the kinds of yarn in the department which

are ready for winding. The new assignment is written on a winding slip which serves as a move ticket for the boys making up assignments and taking the trucks of bobbins to the winder's machine. By the time the operator has cleared her machine of the work that is on it, the truck of bobbins has arrived and she is ready to begin on the new set of cones.

On completing a set, the operator makes out a report on the winding slip which accompanies her assignment, reporting the number of spindles, the number of cones, and any exceptional matter such as a delay. The slips which accompany a set of work are made out in triplicate, one copy remains in the packing room with the set of cones, one copy goes to the Payroll Department for payroll purposes, and the other copy is returned to the operator as a receipt, indicating the work she has done. Before the cones leave the winding machine, they are placed on the top of the machine and an inspector comes and carefully examines each one. The number of defective packages is reported on the slips just described. Each day the waste yarn accumulated from the operation is taken up and weighed.

A spindle report, which gives a summarized account of all the spindles in the room, is made out by the foreman of the department. The delays, interruptions, stops of any spindles, departmental overtime or short time, are indicated on that report, which incorporates in total for the entire room, the same spindle information that is found on the individual winding slips.

THE WINDING JOB

The requirements of the winding job can be seen most easily from the job specifications and the standard instructions which are on file at the foreman's desk and in the employment office. A sample job specification is shown herewith.[3] Duties are listed in sequence by Arabic numerals. The duties listed by letters are those which occur at

[3] The standard instructions for procedure in winding are shown in the Appendix as Exhibit C.

JOB SPECIFICAION

PLANT Annex | DEPARTMENT Winding | NUMBER ON JOB 91

[ ] MALE
[√] FEMALE
[ ] MARRIED
[ ] SINGLE

AGE FROM 17 TO 24
NATIONALITY White
TIME TO LEARN (IF NEW) About 3 Months.
TIME TO LEARN (IF PROMOTED) Short Time After Weaver's Knot is Learned.

EXPERIENCE REQUIRED None
EXPERIENCE DESIRED Any with Yarn
NATURE OF TRAINING

PERSONAL QUALIFICATIONS

PHYSICAL	EDUCATIONAL	PERSONAL	MENTAL	SPECIAL
Endurance Good Eyesight Exact Movement Quickness of Movement	Read Write	Carefulness Patience	Analytic Attention Persistent Attention Distribution of Attention	

CONDITIONS OF WORK

LOCATION	POSTURE	OPERATIONS	GENERAL NATURE	SPEED	SPECIAL CONDITIONS	HEALTH HAZARD
	Standing Walking Stooping	Tying Weaver's Knot	Noisy Light Fine Clean Operative		Permanent Hot in Summer Wooden Floor	ILL.—Good VENT.—Good

DUTIES

1. Change the cones.
2. Start the yarn winding on the cones.
3. Lay out the bobbins, and start new bobbins winding as soon as old bobbin has finished.
4. Stamp finished cones.

A. Tie up all breaks with Weaver's Knot.

B. Clean dirty and oily cones.

C. Clean and oil the machine.

D. Keep track of sets of yarn at the machine, so as not to mix them.

Keep all the cones winding in uniform size if possible, but keep cones winding all the time. Important to watch the work all the time.

E. See that adjustments be made to spindles when necessary.

MACHINES AND TOOLS USED Winding Machine FURNISHED BY Company

HOURS FROM 7 TO 5:30 PAY START AT $10 PER Week PROMOTION FROM ----------

SAT. FROM 7 TO 12 RAISED AFTER 4 Weeks TO $12.50 TO Cone Inspector or to Quilling or Weaving Dept's

OVERTIME ---------- AND AFTER 4 Weeks TO $14.00 RELATED JOBS ----------

Piece Rate Earnings Average from $14.00 to $30.00 per week.

CAUSES OF TURNOVER ----------

REMARKS Advantages—Steady Work and not very heavy
Disadvantages—Noise of Machine somewhat trying on nerves.

FOREMAN EMPLOYMENT MGR.

irregular intervals and must be taken care of promptly as occasion arises.

The winding frame is composed of a series of friction rollers with attachments for holding the bobbins and cones in their proper places and for controling the yarn as it winds. The frame is a little less than five feet high and there are fifty friction rollers about four inches in diameter along each side of the frame. A rack is attached to the frame below the friction rollers to hold reserve bobbins, and a shelf above the rollers holds the supply of cones. Spindles in front of the rack below hold the bobbins from which the yarn winds, and a cone arbor holds the paper cones against the friction rollers while the yarn winds. There are three parts in the attachment for controlling yarn as it winds. One is a tension device to wind the yarn with proper firmness and another guides the yarn to its position on the cone. The third part is designed to clear the yarn of imperfections and is usually composed of a knife and a slub catcher adjusted so as to break the yarn when any large knot or similar imperfection is encountered.

When a cone of yarn is completed, it is about five inches in diameter at the base and three inches in diameter at the top. The pasteboard cone on which the yarn is wound, protrudes slightly at the base and top. The cone of yarn is the finished product of these mills and goes to knitting mills. When a garment is being knit, the cone is set on the knitting frame and the yarn pulls freely from the top, unwinding without the cone revolving.

Yarn comes to the winding department on wooden bobbins which are about one-half inch thick and nine inches long. Only one thread of yarn is wound on a bobbin, each thread being called an end. As the warp is generally 6,000 yards long, it is customary to put 6,000 yards of yarn on each bobbin. If the yarn is very coarse, the bobbin will hold only 3,000 yards of the yarn.

As noted by the specifications, Duty No. 1 is to change the cones. The operator turns the cone arbor (G) out from

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G—See Glossary.

the friction roller (G), pulls off the finished cone of yarn and lays it on top of the machine. From the top of the machine she takes an empty paper cone similar in shape to the hollow cone used for holding ice-cream and places it on the cone arbor. The cone arbor is then thrown back into position and given a spin with the hand to see that it runs evenly and that the paper cone is perfect. A bobbin having been placed on a spindle below the winding frame, the operator starts to wind the yarn from the bobbin onto the cone by drawing the yarn up through the tension device and around the end of the paper cone. The end of the yarn is held in the left hand while the right hand shoves the lever which lowers the paper cone against the friction roller. A guide moves back and forth distributing the yarn on the cone. After having started all the new cones winding, the operator takes from the bobbin truck which is in her alley, all the bobbins for her machine and distributes them along the rack, underneath her machine. After all these bobbins have been laid out, she marks the stamps which are to go inside the cones she has just completed and then sticks the stamps inside the cones at the base, making sure at the same time that the cones are clean. She removes empty bobbins from her frame putting them in the truck from which she secured her full bobbins.

While the yarn is winding, breaks occur. They may be due to any of several causes. A knot in the yarn which catches against the knives causes a break. A slub, or thick place in the yarn, will cause a break. If the yarn has not been wound properly in the Quilling room, it may not come off the bobbin evenly, but in a tangle which will break out against the tension device or the slubcatcher. Whenever the yarn breaks, immediately the stop motion operates and lifts the cone away from the friction roller. The cone continues to revolve for a few seconds and the loose end lies flat against the other yarn that has been wound. Sometimes the operator must hunt a second or two to find this loose end to which she will attach the end from the

G—See Glossary.

bobbin after breaking out the tangle, slub, or knot. The weaver's knot which must be used in tying yarn ends together is a different knot than is used for any household purposes, and therefore requires some training and standard procedure in order that the operator may tie it quickly and correctly.

It is necessary for the operator in looking up the alley where she works, to note any of the cones that are not in position against the friction rollers. This makes some demand for distribution of attention. If she forgets to watch the cones, the yarn may break and the cone where the break occurs will be delayed until the operator ties up the end. The entire set may be held back until that retarded cone is completed, as it is often necessary to remove one set of cones of yarn completely before starting another set. It requires only six to ten seconds for the operator to step over to the place where an end breaks and tie it up. If she is talking with some other operator for two minutes after an end breaks, before she notices that the end has stopped winding, she has a loss of winding production ten times greater than the circumstances require. The same may be said of laying out bobbins. If she fails to distribute them along her machine, none will be convenient when a new bobbin is to be tied on, and the winding will be delayed until she goes to the box or truck and secures the needed bobbins. And if, for example, the winder fails to bring back a new set of paper cones as she returns from the desk of the foreman, she will be compelled to leave her machine again and perhaps several cones will stop winding while she is away. Thus persistence of attention is required.

It is expected that each winder will watch for imperfections. She is given instructions how to note any of these difficulties and to whom to report. A troublesome imperfection is cross winding. If the yarn is thrown across the bottom of the cone instead of being wound up to and along the bottom edge of the cone, it will cause a jerk or even a break when it is being pulled off the top of the cone in

knitting. The extra tension would cause imperfect proportions in the knitted garment and a break in the yarn would necessitate re-threading the knitting machine. Even ridges on the bottom of the full cone affect the tension so as to cause trouble in certain kinds of knitting. The winder is expected to see whether previous inspections have failed to discover any yarn which has hard or slack twist (G), and to note any discrepancies in the size of the yarn. The wrong size or a three-ply yarn (G) in place of a two-ply would make an uneven place in the finished fabric.[4]

She must watch for soiled yarn or any mixture of yarns. Final inspection is important to prevent difficulties in knitting. The proper moisture greatly facilitates the handling of yarns as it makes the yarns stronger, softer and less inclined to perform the queer antics of dry yarn with static electricity in it. Normally there are eight or nine percent of moisture in all cotton yarns and fabrics. The inspector learns to tell by the feel of the cones whether they are too dry and apt to give trouble in handling. She is also responsible for reporting anything about the machine which needs the attention of the machine fixer. All this careful observation calls for analytical attention or discrimination.

At several points waste yarn occurs. A small wad of yarn is broken out whenever a tangle occurs. In tying up broken ends, the operator makes some waste by breaking off weak places or frayed ends. Some yarn is broken off as the operator "jockeys" the yarn into position to tie a weaver's knot with short ends.

The operators are requested to watch for "bad bobbins." These are bobbins on which the yarn is mixed. The winders are asked to lay aside these bobbins of imperfect yarn.

There are many minor features of the winding operation

G—See Glossary.

[4] Ply in yarn refers to the number of strands. A single ply has only one strand; a three ply has three strands twisted together in the direction opposite to the twist in the strands themselves.

in which there is opportunity for developing skill.[5]

The placing of bobbins on the spindles below the frame is an example. A novice is apt to strike many bobbins against the top of the spindles whereas a skilled operator slips each bobbin down over the spindle without missing the hole. The delay when a bobbin does not slide onto the spindle directly seems negligible. The operator merely shifts the position of the bobbin to make the hole in the bottom of the bobbin come directly over the spindle. Only a second or a fraction of a second is lost, but a winder may place eight hundred bobbins a day on spindles. Besides losing a few minutes a day, there is fatigue involved in being compelled to try two or three times to do what she expected to do in one movement.

Another part of the operation is finding the loose end on a cone, to which the end on the bobbin is to be tied. A glance of an experienced operator generally shows her where to reach for the end. If the glance does not reveal the yarn on which there is no tension, her practiced fingers come to her aid. She rubs her fingers lightly over the cone in such a way as to cause the loose end to move slightly. Then the end is immediately grasped between the forefinger and thumb almost in the same movement with that of finding the end by feeling for it. Colored yarn does not reflect the light as does white yarn, so the loose end is harder to find. Sometimes an operator spends as long trying to find the loose end as would be required to tie the knot. Expertness comes only with continued practice.

[5] This brings us to a phase of shop work least appreciated. It is comparatively easy to learn to operate the machine. Much more subtle is the knowledge and control of the materials of trade. While we have really made headway in the standardization of certain processes, much remains for research in the field of raw materials. Still more detailed should be the study of the control of these materials at different stages of manufacture. There is here a real problem which should command the thought of the many students who are now fooling themselves into thinking that they are passing as real workers in industry. To contribute anything valuable one would have to stay in an industry long enough to experience some of the later stages of learning instead of the first thrills of a new environment. Bezanson, Anne. "Skill" in the Quarterly Journal of Economics. Vol. XXXVI. August, 1922.

The tying of the knot involves considerable skill. A superior operator learns to take the loose end from the bobbin with one hand while picking up the loose end from the cone with the other hand. The winder who wraps the yarn about her hand more than once to "jockey" the yarn into a convenient position and tension for tying the knot, takes a fraction of a second extra and makes the extra movement which is only to be considered because it may happen six or ten hundred times a day. In swinging the yarn around the left thumb, it is easy to pull it too tight or leave it too loose. If too tight, the look will not roll off the end of the thumb and permit the end to be pushed into the loop; if the loop is too loose, the end will slip away before the loop can be drawn firmly around it. In each succeeding movement of making the weaver's knot there is a little knack, which, however slight, makes a considerable difefrence in the output in a week.

Each winder must keep her own machine clean. Several times a day the lint or dust is to be wiped from the machine. There is a small smooth place on the machine where the dust collects. Once each week the operator cleans the machine thoroughly. It is stopped completely for the cleaning operation. Every day the operator oils the cone holders. She does this when she has doffed one set and is about to start another. The oiling of the machines requires but two or three minutes.

There is nothing very arduous or annoying about the winding job. There are no heavy materials or equipment for the operator to lift. All the working materials are light in weight and clean. An operator must stoop a great many times a day in order to get the bobbins from the truck in which they are brought to her. It is not a hard thing to do once one becomes accustomed to the stooping or the bending over. The noise of the room is caused by the whirring of the machines and is not high pitched or clanging. It takes only a few days for the operator to become accustomed to the sound of the machines.

There is an occasional opportunity for the winder to sit

down. Straps about six or eight inches wide are attached to the ends of the machines and are looped across the alley way that is about four feet wide. If the work is "running bad" the operator must be on her feet all the time going from cone to cone tying up the broken ends. If the work is "running well" she can sit down for several minutes at a time.

From the viewpoint of the operator, the job may be described as clean, light, repetitive although not without change; it is likely to cause fatigue only for those who might be indisposed to standing and stooping; it makes a demand for good hand and eye co-ordination, requires no particular amount of education or mental ability, but exercises attention, especially analytical and persistent attention.

CHAPTER IV

RATING WINDERS WITH REFERENCE TO QUANTITY OF PRODUCTION

In winding, emphasis is placed upon quantity. Quantity is the basis of pay and therefore is of greater interest to the operator. Quantity is involved in meeting production schedules for sales requirements. Inferior winding does not destroy the material, usually the yarn can readily be re-wound. There is not very much waste yarn and the machines do not get in very bad condition from careless operation. Hence we may well give our attention first to quantity of production.

A discussion of production rating cannot ignore the conditions under which the production takes place. As mentioned in a previous chapter, one of the first steps is a study of the conditions with a view to standardizing them or making allowances for each significant change in conditions. Before attempting to make an application of a rating plan it is necessary to consider the variables with reference to standards. The table on the following page lists these variables, and indicates the extent to which they exist in the four mills under observation.

VARIABLES

Materials. The variation due to counts is one of weight. A thousand yards of a 20/2 is only one-half as heavy as the same length of a 10/2. A 20/2 yarn is only one-half as large as a 10/2 and consequently, if there are no interruptions, it will take the winder twice as long to wind a pound of 20/2 at it will of 10/2. Allowance must be made for this in whatever rating plan is applied.

In the trade practice, weight is the uniform measure of quantity of yarn. It is purchased by the pound from the spinners, and is sold to the weavers and the knitters on a pound basis. If the winding mills attempted to establish some other unit such as cone or warp, it would lead to many complication, and make it very difficult to keep track of the production schedule that is necessary to meet

orders which are always in the form of pounds. The pound basis is therefore likely to continue.

VARIABLES

		Mill A	Mill B	Mill C	Mill D
Materials:	Counts (size of yarn)	30A	30A	20A	20A
	Spinnings (kind or quality)	50A	50A	45A	40A
	Bobbins (size or kind of package)	3	3	2	2
	Conditions	V	V	V	V
Machinery:	Types	1	1	1	1
	Models	1	1	1	1
	Accessories	1	1	1	1
	Adjustments of accesories	3	3	3	3
	Speeds	2	2	2	1
	Conditions	1	1	1	1
Processing:	Kinds of cones to be made	3	3	2	2
	Kinds of knots required	1	1	1	1
	Special care or directions in handling	E	E	E	E

(Common to all mills)

Interruptions:	Delays	Machine care or adjustment Equipment breakdown Lack of materials Failure to handle materials or assignments promptly,
	Lay-off	Lack of coordination of departments Plant difficulties from storms, fire, accident, etc. Lack of manufacturing orders
Working Conditions:	Physical	Heat, light, noise, humidity, ventilation, vibration, odors, dust, conveniences of drinking water, lockers, wash rooms and toilets.

Training and Instructions:

Personal Environment:

A—More or less depending on yarn, market, seasonal demands and other trade conditions.

V—Varies with weather and with lots or assignments, but uniform in each lot.

E—Experimental

The differences in spinnings (G) is a possible difference in quality of yarn. The yarn from some spinners may not be as strong as the yarn from other spinners, or it may have more knots, slubs (G), or other defects. These cause the yarn to break as it is being wound, occasioning more work for the operator, and requiring more time to complete a set of cones. That one spinning is weaker than another is

G—See Glossary.

not necessarily a sign that the yarn is inferior. It depends entirely upon the purpose for which the yarn is intended. It may be that the weaker yarn is so because of less twist in order to make it softer. To the winder these differences in spinnings in yarn man but slight differences in her work.

It should be mentioned that although in Mill A there are thirty counts and fifty spinnings, there are only from ninety to one hundred fifty varieties of yarn by combinations of counts and spinnings, the number depending on market demands for yarn and knitted goods.

There are usually only two kinds of bobbins on which the yarn comes to the winder, a small bobbin for fine yarn and a larger bobbin for coarser yarn. In each of these mills, special consignments are received, the bobbins of which are very large and hard to handle. The special consignments do not all go to the persons who are on day rate. Since some of it goes to the regular operators who are classified in this rating plan, we must be sure that the proper allowance is made for this kind of work.

Machinery. It happens that all of these mills use the same kind of winding machines. The machines are not only of the same make but they are similar in model; the changes that are made by way of overhauling or improvements are carried on in a similar way in all of the mills. It is customary for such service to be supplied by the firm that manufactures the machines.

There are a number of attachments which may be placed on the machine, and which will make some difference in operating time. Among these are the tension base, knives, washers and slub catchers. (G) The makers of the machine furnish uniform attachments and equipment to all companies who wind similar kinds of yarn.

There are three adjustments made with the attachments. One breaks out every defect or knot in the yarn. A second adjustment breaks out knots or other defects which are too large to pass through the gauge as set. A third allows the

G—See Glossary.

yarn to run continuously except where there are tangles or other big imperfections.

Variation in speed comes in the number of revolutions per minute of the friction roller against the paper cone or yarn winding on the cone. There is a difference of three percent from the slowest to the fastest, but usually there is a difference of only one-half of one percent. Variation in speed is accounted for mainly by the difference in the load that may be on the machine. A machine which has one empty side may run two percent faster than a loaded machine. Another cause for variation in speed is a loose belt, although this rarely occurs as the belts are inspected every two weeks. A loose belt is quickly detected as the cones will "go bad." The operators are trained to note this, and to call the attention of the machine fixer to the condition. If for any reason the operator fails to note the condition while the cones are being wound, the inspector of cones will see it at the time that the set of cones is finished. In one mill six percent of the operators have a different set of pulleys on their machines, making the speed from 11% to 12.3% lower than the speed of the other machines in the room. The operators who work on these slow machines handle special kinds of yarn, more particularly bleached yarn. In figuring their production rating, special consideration is given to these factors. For the present our discussion will be based upon the regular operators. The machines are not delicate, nor do they undergo hard service. Due to these facts and the care given them, they are quite uniformly in good condition.

Processing. The size of the cone of yarn, the finished product, is usually standard. Occasionally there are smaller cones, and this requires more frequent doffing—taking off the finished cones and putting on new ones to be filled. To this variable some consideration must be given in the rating plan. Experimental changes are such as may be attempted from time to time by any company. They are not numerous and affect but a few operators who are usually on day or special rates.

Interruptions. It is a standard practice in all of these mills, in case a piece worker is interrupted for any considerable time, for the foreman to make out an allowance slip for her, and put her on a day rate. The interruptions that ordinarily occur are for a few minutes only and no allowance is made. Oiling has already been mentioned. All the operators have the same oiling task each day. As leather belts are used on all these machines, the machine tender, not the operator, sometimes dresses or tightens a belt. The belt difficulties that an operator may have, would possibly amount to ten minutes a month. The oiling of the bearings, motors, and other parts of the machinery is taken care of regularly by machine tenders who use overtime to make all the special changes, and to take care of any overhauling of machines that should be done. Waiting for materials or assignments, is perhaps common to many departments in many different industries. It is not uncommon in these winding mills although it is not very frequent.

If these winding departments have not enough work for all the operators, usually the entire departments are sent home. Thus there would not be idle operators waiting in the department for a long period of time while others were at work. It sometimes happens that a few operators complete their sets and wait a few minutes before new assignments reach them. These small delays are not accounted for in individual production reports of these mills, and to this extent all the records may be in error. There is no reason why any certain operator or operators would have delays and others not, therefore in a year's time or perhaps even in a month's period the delays may be distributed in such a way as to make the amount of error the same for all operators. As there are some weeks when no waiting for work occurs, this element may not be very significant.

Working Conditions. So far as it is possible to maintain uniform conditions throughout the entire room there are no differences in temperature, humidity, or light. The lighting is very good. There are seldom any complaints from the operators. In one mill, three operators once com-

plained about the heat from a certain pipe which passed through the room near their place of work, but after it was covered with asbestos, there was no further complaint.

Training. The training is not uniform, although it tends to be so due to standard methods of operation. In one of these mills the training is fairly uniform as all the new operators are given instruction by a certain teacher. In the other three mills, the training is given first by one operator and then another and as a result of the varying teaching abilities, some learners may have good training and others inferior. Differences in teaching ability of trainers are partly offset by the personal supervision of the foreman and the standard procedure which all winders are supposed to follow.

Personal Environment. The personal environment varies considerably and cannot be completely standardized. It is a matter which, though important, will always be somewhat intangible. One operator's work place may be near the drinking fountain. As her friends come to get a drink several times a day, they may stop to say just a few words each time. The total result on the production of a friendly, talkative person might be serious. A quiet, steady operator in the same location might save time by never leaving her machine to get a drink and by recognizing salutations and comments by a mere nod as she keeps at her work. Likewise the location near the foreman's desk may be favorable or unfavorable depending largely upon the operator herself. She may spend so much time trying to hear what the foreman says to callers that her production suffers, or she may feel constrained to do her very best work when in such proximity to her supervisor. Operators are more congenial with certain ones than with others, lending assistance and even trying to keep running the machine of an operator who is temporarily away from her machine. Sometimes rivalry between certain persons is a stimulant to good production. The foreman is wise who is sensitive and judicious regarding the personal environment of the operators in his department. Not because of its unimportance but because

of its intangibility in these mills, the personal environment is not taken into consideration in this employee rating study.

BASIC RECORDS

Before we can determine how best to rate winders with reference to quantity, we must look into the reports that are available from which to determine the total production of each winder for a given period. Our aim to make a reasonable, fair and useful rating of winders is not to be set aside because we do not find reports complete in every detail. However, our procedure will depend largely on what data are available or what may be made available. The preview of available reports is advisable to determine which data are most significant and what useful summaries can be made with the least clerical effort. The clerical load may be heavy enough to discourage some mill men from attempting the rating study. Clerical work is not only a cost but a burden of supervision. Therefore the simpler and shorter the calculations to get the desired facts, the better.

The most accurate summaries made of the winder's work are the weekly tabulations for payroll purposes. The operator herself may have a record of her work, noting it on a card at her machine, or she may have the winding slips which come back to her from the packing room after her sets of cones have been weighed. Her own personal record could not be used as a basis of rating, because it would be hard to read the writing of some of the winders, and there would be liability of error or criticism if production ratings were based on the operator's own compilations. The winding slips showing the counts, spinning, and weight of each set, are the basis for payroll summaries. In these mills there are no other complete records of production of each operator, except some that are abstracted from the payroll tabulations. It is therefore with this payroll tabulation that we should undertake to formulate production summaries that will serve suitably in rating the winders, or else we must request some report other than that currently made. In any case, it is best to endeavor to get the informa-

tion needed from payroll tabulations as then it will be regular, it will have its accuracy checked, and it forms a part of the permanent file which is readily accessible. A sample of the data available from the payroll is shown in the following table.

SAMPLE TABULATION OF PAYROLL

Operator	Count	Spinning	Weight	Rate per C.	Amount of pay
231	24	0106	50	$2.02	$1.01
	35	1302x	209	1.54	3.22
	38	1302x	88	1.49	1.69
	38	2306	91	2.26	2.06
	42	1101x	157	1.72	2.70
	44	1311	104	2.30	2.30
	48	0313	89	2.48	2.21
	58	1001x	60	2.34	1.40
	68	2201	50	2.85	1.43
	Total		898		17.91

x Special rate paid for this spinning.

The nature and form of the production summaries will limit to some extent the purpose for which they may be used. It other words, the kind of rating to be done will be determined by the possibilities of the records available. To see what can be done with the payroll tabulations, it is well to attempt to apply typical rating plans as described in Chapter II.

SELECTION OF A TYPE OF RATING

ABSOLUTE RATING

In an absolute rating plan, the winder's production is compared with that production which she would have made, had she kept her machine running perfectly the entire period. At first glance one notes that the operator wound a total of 898 pounds of yarn, but an attempt to express in pounds what would be perfect production meets obstacles. One pound of 24s 2-ply contains 10,000 yards and will wind in about one half the time that it takes to wind one pound of 48s 2-ply which contains 20,000 yards.[1]

[1] There is a slight difference involved in that a bobbin of 24/2 might contain only 3000 yards whereas a bobbin of 48/2 would contain 6000 yards. The winder would therefore have to change the bobbins of 24/2 more frequently in winding a given yardage than if she were winding 48/2.

One week the winder may have a preponderance of heavy counts and the next week she may wind medium and fine counts. Poundage cannot be used as a unit of measurement unless the size of the yarn in the pounds is known. To make a comparison in pounds between the 898 and what she might have wound, the pounds in both cases may well be expressed in a common denominator, such as 24s 2-ply. The calculations necessary to reduce the pounds of different counts to equivalent pounds of 24s is shown in the table below.

TABLE OF EQUIVALENT WEIGHTS

Count	Spinner	Weight Coned	Multiply by	Divide by	Equivalent weight in 24s
24	0106	50			50
35	1302	209	225	154.3	304.76
38	1302	88	225	142.1	139.34
38	2306	91	225	142.1	144.09
42	1101	157	225	128.5	274.90
44	1311	104	225	122.7	190.71
48	0313	89	225	112.5	178.00
58	1001	60	225	93.1	145.01
68	2201	50	225	70.4	141.69
	Total	898			1568.50

Note—By equivalent weight is meant the weight which in the specified count would amout to the same winding length as the given weight of the other count.

Although this calculation may be worth while in some instances and for certain purposes, it constitutes too much clerical work to be practical in a rating scheme. It is advisable, therefore, to turn to some other way of stating the production of the winder.

Instead of stating the production in poundage, it is possible to state it in terms of yardage. Taking the Payroll Schedule we can determine the number of yards wound by that operator during the week in the following manner: As given by the standards used in the cotton trade, the weight of a thousand yards of each of the counts is shown in the yardage table A. The weight wound in each one of these counts is divided by the weight of a thousand yards and the result will show the thousands of yards wound by the operator.

YARDAGE TABLE A

Count	Weight of 1000 yards	Weight Coned	Thousands of yards coned
24	.1	50	500
35	.0682	209	3060
38	.0626	179	2859
42	.0566	157	2774
44	.0541	104	1941
48	.05	89	1780
58	.0411	60	1460
69	.035	50	1428
Totals		898	15802

By a series of tests it is discovered how many spindle minutes are required to wind 1000 yards of yarn. The time required is, say, 4.4 spindle minutes. The operator's working time for the period multiplied by the number of spindles on her machine gives the total spindle minutes worked during the week. This total divided by the figure 4.4 gives a result of 24,188 which is the total yardage that could be wound in the time worked by the operator. The actual production of the winder being 15,802, her absolute rating would be but 65%, as 15,802 bears that relation to 24,188.

There is a possibility of getting the yardage of production by another method. The clerk of the winding department, or the forman making assignments, can make on the winding slip a notation of the number of the bobbins per cone and the length of yarn per bobbin. Extension can then be made from winding slips returned from the packing room, thus securing the total yardage per set and the addition of yardage figures of all sets would give the total for the period of time.

The use of either poundage or yardage figures seems unsatisfactory. In either case a great deal of extra clerical work is involved. The use of yardage figures results in rather high figures; and it is well to recall that sales requirements and production schedules are all listed in terms of poundage.

It would not be advisable to decide to use the Absolute rating plan in preference to any other rating plan without

examining the other types of rating. It will be of interest to go on with a trial application of the other types of rating or at least to indicate how they may be worked out and applied. Such an investigation will bring out concrete explanations of conditions existing in the mills and of features of the various types of rating. The information thus brought together will furnish grounds on which to choose the type that will be most serviceable under the circumstances existing in these mills.

STANDARD RATING

Whereas Absolute Rating makes no allowance for any delays or hinderances in production, Standard Rating aims to make an allowance for every significant variable. Therefore, the proper time for winding each unit of yarn will have to be determined for each count and spinning, wound under every condition and kind of processing. Proper delay time per unit will be added to this time so determined. It may be found that No. 1302 spinning runs uniformly in three percent less time than No. 2306. Or we may find still further complications in that No. 1302 spinning in 38/2 might run three percent better than the No. 2306 spinning, but these spinnings might have the same running qualities in the 68/2 count. When these standard times have been determined for each of the different spinnings in each of the different counts, the total standard time may be determined by multiplying the quantity of each by its respective standard time. This total standard time may be then compared with the actual spindle minutes and this comparison will show the efficiency of the operator. In a sample schedule shown on the next page the clerical procedure is indicated.

At the outset we noticed that there was what seemed to be considerable lack of standardization. As there are ninety to one hundred fifty combinations of counts and spinnings and still other variations in bobbins or processing, the problem becomes complex. When, however, it is known that the same spinning may differ from year to year, this

SAMPLE OF STANDARD RATING

Count	Spinner	Weight Wound	Attending Conditions	Standard time per lb.	Job Standard Time
24	0106	50	AXR	.0290	1.45
35	1302	209	AXS	.0400	8.36
38	1302	91	AXS	.0485	4.29
38	2306	91	AXR	.0478	4.35
42	1101	157	AXS	.0555	8.71
44	1311	104	AXR	.0565	5.88
48	0313	89	AXR	.0560	4.88
58	1001	60	AXS	.0715	4.29
68	2201	50	BXR	.0805	4.02

Total Standard Job Times----------46.32
Total actual time taken as shown by time card----------53.75
Total percent of efficiency----------86.2

A—A type bobbin, B—B type bobbin
X and Y indicate speed of machine
R—Regular knife adjustment, S—Special knife adjustment.

offers further resistance to standardization. One would hope and presume that by testing the yarn, its winding qualities would be determined. In its present state of development, yarn analysis fails to indicate definitely the running qualities of the yarn. It would require regular tabulations of all running times on each count and spinning under the various circumstances in order to set standards suitable for such records and these standards would be subject to revision with each new spinning and each new cotton crop. Not only is there a lack of standards of performance but any standard is ever subject to revision. One lot of a certain count and spinning may wind better than the next lot. This may be due to rougher handling in transit between spinner and winding mill, or it may be due to some differences in material or handling in the processes at the spinning mill. Possibly it is caused by the spinner's being unable to secure a uniform fibre, a difficulty which often occurs as the cotton fibre from one part of the country differs in quality from that of other parts of the country even though the staple (G) may be of the same length. And too, the fibre from one part of the

G—See Glossary.

country varies from year to year, a variation ascribable to weather conditions. Consequently it is impossible to get raw material which in the very strictest sense of the word is standard.

In spite of the variability in raw material, usable standards can be set up. These winders are paid on a piece rate basis. If the material varied too greatly there would be serious objection to piece rates as the operators' earnings would be too uncertain. Although the running time for given weights of yarn varies between counts, there is not a wide fluctuation in winding time as between different spinnings. For example, if winding times were recorded for different counts and spinnings, it might be found that certain spinnings run more or less uniformly, and the deviation from the average could be noted. Gradually the standards could be built up, revised, and the usual deviation determined. A standard with a known probability of error is serviceable. From the operators there are seldom any criticisms regarding proper balance in the piece rates which are based on the standard times determined from past experience. Furthermore, these mills are steadily improving their standards.

RELATIVE RATING

The other type of individual production rating plan, as described in Chapter II, was termed Relative Rating. Whereas in Absolute Rating the employee's production is compared with theoretical perfection, and whereas in Standard Rating it is compared with a set standard, in Relative Rating each employee's production is compared with that of the other employees of the department. Relative production rating may be said to be ranking employees with respect to their output.

The question still remains, however, as to how quantity of production can best be summarized for the purpose of comparison. Total pounds could not be used as the finer counts require two or three times as many spindle minutes per pound as coarse counts. Total yardage has the same

faultiness as total pounds in equivalent count. Standard times for each count would be more useful. In a general way standards are already in use, these standards being the rates of pay for the different kinds of winding done. This circumstance presents another alternative, namely, to use earnings as production summaries.

Investigation of the possibility of using earnings as a basis for individual production rating will necessitate an inquiry in these directions: First, is the schedule of rates paid carefully worked out with references to the proper time that it should take to wind yarn under each different condition? Second, if the rates do not correspond to each change in the variable, is there a fair distribution of these different materials, and kinds of processing, so that each winder has the same amount of good and bad as every other winder?

In answer to the first inquiry, the pay rates are based on tabulated experience and are intended to compensate for working difficulties in a fair and just manner. These rates differ as to counts so that the pay for winding a pound of fine yarn is satisfactory recompense for the longer time required. Rates also vary as to special knife adjustments. But there is no change in rate for spinning or for other minor variables which have very little effect on the operation. All these variables are averaged in the rates set by experience. The experience of these mills ranges from three years in Mill D to eighteen years in Mill A. The average earnings of the operators are watched closely as a barometer of running times and wage rates. Although the rates may not be perfectly correct in every detail, there are factors which always tend to correct them.

The second question concerns the distribution of the work in the winding mills, to determine whether each winder gets her turn at good and bad work as it comes along. There are certain reasons why evenness of distribution exists and will continue to be regular in spite of the possibility of favoritism by foremen or carelessness of clerks who may

assist in giving out work assignments. First, when any lot or consignment comes into a winding department, it is best for the foreman to get all of that consignment out of his department at one time. One object of this is to meet the requirements of the manufacturing schedule; another is to avoid the department having so many different kinds of yarn and consignments that will require many trucks and much floor space to take care of what may be called lot ends. Furthermore, the foreman finds that it is less likely to result in confusion or mixing of yarns if the entire consignment is pushed through the winding room at one time as rapidly as possible. Thus each lot is distributed over the entire room and each operator has a good chance of securing one or more sets of each consignment. The foreman also discovers that if all the operators are put on the same kind of work at the same time there is a better feeling throughout the room. If one operator should run fine yarn for a considerable part of the day, and the operator next to her should run coarse yarn through the same period of time, and if it happened that the operator who had the fine yarn thought she liked coarse yarn better, and vice versa, resulting feelings might tend to retard the production of both. The occasional change in size of yarn appeals to most operators. It is, therefore, a standard practice to distribute throughout the department each consignment in turn as rapidly and as completely as possible.

That the distribution is even is shown by a study of the production reports. A single week was studied carefully, the kind of work for each operator being listed in detail. It was found that of a certain count and spinning, there was an average deviation of 15.8% in the weights wound by the various operators. Two items comprised about one-third of all the work for the week. It is to be remembered that if only one operator gets fine counts and another coarse counts, they may receive equal amounts of pay but one will turn out only one-half the poundage of the

other. However, there was only an average deviation of seven percent in total poundage. The standard deviation of total weights wound was 8.38%. The average deviation in piece rate earnings was 7.07%; the standard deviation was 8.61%. The coefficient of correlation between total weights wound and piece earnings was plus .94. Examination of total distributions of work to winders over longer periods indicates corresponding uniformity. (See following table.)

Under the circumstances existing in these mills it seems best to use earnings as the basis for comparisons of individual production. To use earnings in this way summarizes production in terms in which the employee is always calculating, and it provides the foreman with concrete extensions which appeal to his understanding and interest. For the management, individual production rating with earnings as a basis furnishes a check against the lack of adjustment in piece rates payroll, and it provides a detailed commentary on average wages and labor costs per unit of production. Utilization of piece rate earnings as a basis for rating reduces the clerical work to a minimum. Figures of earnings are tabulated regularly and recorded permanently for reference. It is convenient to compare the total hour worked in any period with total earnings. On account of the ease in getting these figures, their simplicity, their high degree of accuracy, and their usefulness in the given circumstances, it is best in the introduction of this individual production rating plan to make use of the earnings as a basis for relative ratings.

DEVIATIONS IN WORK DONE BY INDIVIDUAL WINDERS IN ONE WEEK AT MILL C

	Deviation from Average Weight of Most Common Kind of Work.	Deviation from Average Weight of Next to Commonest Kind of Work.	Deviation from Total Weights.	Deviation from Average Earnings.
1.	—21.6	46	—87.5	—2.26
2.	17.4	50	88.5	2.38
3.	—52.6	4	11.5	.90

4.	113.4	8	31.5	.32
5.	—64.6	—85	—142.5	—3.09
6.	—140.6	52	—68.5	—.51
7.	—99.6	2	—13.5	—.54
8.	44.4	12	81.5	2.05
9.	—93.6	—38	—121.5	—2.66
10.	—99.6	8	—26.5	—.10
11.	36.4	56	34.5	1.64
12.	—180.6	—127	151.5	
13.	—97.6	—42	—41.5	—1.29
14.	—105.6	10	—164.5	—3.60
15.	32.4	5	47.5	+1.25
16.	—100.6	—136	—85.5	—2.22
17.	71.4	—89	—115.5	—2.61
18.	—51.6	18	—54.5	—.54
19.	—138.6	122	2.5	—.72
20.	20.4	4	—97.5	—1.87
21.	—92.6	4	75.	.30
22.	—21.6	1	43.5	.98
23.	—65.4	—42	59.5	1.25
24.	—94.6	99	70.5	1.12
25.	56.4	—3	18.5	1.63
26.	—54.6	2	—5.5	—.02
27.	—26.5	7	36.5	.81
28.	129.4	—34	178.5	3.07
29.	—5.6	101	114.5	2.36
30.	—32.6	44	—41.5	1.05
31.	62.4	5	33.5	1.42
32.	—49.6	14	82.5	1.47
33.	157.4	—135	74.5	1.56
34.	—50.6	0	—63.5	—1.39
35.	—24.6	—70	40.5	.32
36.	7.4	—44	—72.5	—2.40
37.	—48.4	—29	—132.5	—1.75
38.	48.6	14	83.5	1.02
39.	14.4	100	80.5	1.79
40.	.6	13	—14.5	—1.19
41.	48.6	2	4.5	.60
42.	50.4	3	119.5	.46
43.	72.4	107	113.5	4.56
44.	128.4	—34	—109.5	—2.23
45.	15.6	—37	73.5	1.15
46.	38.4	13	—24.5	—.17
47.	11.6	60	116.5	2.77
48.	54.6	2	47.5	.02
49.	8.6	152	104.5	1.09
50.	38.6	—83	—58.5	—1.49
Average Deviation	23.2%	15.8%	7%	7.07%
Standard Deviation			8.38%	8.61%

Coefficient of correlation between total wound weight and total earnings, plus .94.

There are advantages and disadvantages in using the Relative Rating plan in these mills. This type of rating does not show how much time is lost by idleness or slowness of the operator; conversely, it does not show what perfect performance would be or what level of attainment should be expected. On the other hand, it does present a summary of what the operator has done in the given period, and sets that record in rank with the records of all the other operators who did the same kind of work in the period. It thus forms the natural first approach to the efficiency question from the point of view of the foreman and employee. Comparison can be made between the fastest and the slowest operators and the average of the group. The foreman will surely want to raise the average during the next period. After the foreman has made efforts to bring up the slowest and to keep up the best, he will wish to compare the record of each operator with what would be perfect production, or with a reasonable standard. Relative Rating is the most practical type of rating when individual production is first introduced but **Standard Rating** is a logical development.

APPLICATION

In Relative Rating the production summary of each winder is ranked in the list of all operators of the department who are on similar work. The first step was to list the total average hourly earning of all the winders of the department for a period of six months. The very lowest, and these were stragglers, were set aside as undesirable records,—usually from three to seven percent of the total number of operators were designated as D class. The other three classes, C, B, and A, designated poor, fair, and first class respectively. The mean average of the remaining earnings were found and that figure was set as a middle point in the range of Class B operators. The mean average was approximately the same as the median between the high and low marks. The range from that lowest production to the highest was divided equally, making an equal

number of points or cents in each of the three groups, Class A, Class B, Class C. The distribution of the winders in these classes is set in the following tables opposite the opinion rating which the foreman gave.

CLASSIFICATION OF WINDERS
Mill A, First Half, 1924

	Number of Cases as Per Foreman's Opinion Rating	Number of Cases as Per Factual Production Rating	Number of Agreements
Class A	41	22	20
Class B	56	45	26
Class C	0	26	0
Class D	0	4	0
TOTAL	97	97	46 or 47.4%
	Second Half, 1924		
Class A	12	33	9
Class B	100	57	53
Class C	7	25	4
Class D	0	4	0
TOTAL	119	119	66 or 55.5%

CLASSIFICATION OF WINDERS
Mill B, Second Half, 1924

	Number of Cases as Per Foreman's Opinion Rating	Number of Cases as Per Factual Production Rating	Number of Agreements
Class A	87	41	35
Class B	69	84	41
Class C	--	23	--
Class D	--	8	--
TOTAL	156	156	76 or 48.7%

CLASSIFICATION OF WINDERS
Mill D, First Half, 1925

	Number of Cases as Per Foreman's Opinion Rating	Number of Cases as Per Factual Production Rating	Number of Agreements
Class A	40	17	16
Class B	51	45	23
Class C	6	22	5
Class D	--	13	--
TOTAL	97	97	44 or 45.4%

CLASSIFICATION OF WINDERS
Mill C, First Half, 1924

	Number of Cases as Per Foreman's Opinion Rating	Number of Cases as Per Factual Production Rating	Number of Agreements
Class A	25	14	13
Class B	33	31	19
Class C	1	11	0
Class D	0	3	0
TOTAL	59	59	32 or 54.3%
	Second Half, 1924		
Class A	9	8	6
Class B	48	34	23
Class C	0	14	0
Class D	1	2	0
TOTAL	58	58	38 or 65.5%

The comparisons between the opinion ratings by the foremen and the factual ratings bring some interesting and important points into view. It reveals first of all that the first time a foreman is called upon to rate his employees, he is apt to consider that about half of them are A, No. 1, first class operators. The combined figures of the four mills gives the following groupings according to the opinions of the foremen.

WINDERS IN ALL FOUR MILLS

	Percentage as Per Foremen's Opinion	Percentage as Per Factual Rating	Percentage of Agreement
Good	48.4	23.8	21.4
Average	49.7	52.1	28.1
Poor	1.9	18.5	1.3
Unsatisfactory	--	5.6	--
	100.0	100.0	50.8

Neither to themselves nor to the management do the foremen admit that they have third class winders, except in very rare instances, or until some incident occurs which causes a foreman to decide to discharge the operator. It is to be noted in this connection that some of the winders

separating from these mills were given a lower rating at the time of separation than at the time the ratings were called for. It is strange but true that in relative ranking, a foreman can have *good* and *average* operators and no *inferior* ones, although a statistician would find it impossible to make such a grouping without having some inferior ones to offset the superior ones and thus establish an average or an average group. On second trial, the foremen improved the distribution of operators in the rating scale.

There is much more serious objection to the opinion rating of the foremen than that the grouping of winders by foremen lacks the symmetry of normal distribution. The serious side of the problem is the fact that the foreman does not know who are the inferior operators,—the very ones who most need the recognition and assistance of the foreman. The good operators may well be left alone; they are getting along all right and need no further special attention unless they begin to fail. The ones who are in need of extra discipline, training or encouragement are the inferior producers—the indifferent, the slow or the discouraged. However, these very ones apparently do not catch the foreman's attention. Thus it seems from the way the foreman ranks the employees of his department, he fails to know or note the great possibilities for improvement in individual production.

A word should be said regarding the effect of publishing ratings of employees. Posting the ratings may or may not have a good effect, according to the way it is done. The operators lowest in the list may not feel very comfortable about the publication of their ratings. It is also possible that the highest operators may become the objects of jealousy or other unpleasant feelings. Rivalry, if too keen, tends to lessen the spirit of cooperation and helpfulness which is a valuable aid in any department. There are, however, certain favorable results that might be obtained. The laggard might be stirred to more earnest effort. Many of the operators may be eager to improve their records. It may

arouse and stimulate favorably the whole department to know that the management is so concerned about their productive output.

It has seemed best not to ask the foremen in these winding mills what they think about the value or use of the factual ratings. An indirect comment which tells a great deal is the refusal of the foreman to use their own opinion ratings any longer with reference to the quantity of production. They now depend on the factual ratings and insist upon getting the facts instead of making their own guesses about operators. One foreman remarked that he had referred to the factual data thousands of times in the six months period until another set of reports was available. He had taken particular note of the inferior operators and had studied them to see why they were doing so poorly. His department now shows high production per machine hour. Not only have the foremen been furnished data to guide them in follow-up of individual production, but additional interest is gained in promoting the average earnings of the operatives from one period to another. Instead of feeling as before, that an increase in earnings depends so much on a raise in rates, the foreman, and in turn the operators, more clearly realize that substantial increases can be made by individual improvement.

COMBINED GROUPING OF WINDERS IN ALL FOUR MILLS
STRAIGHT LINE ——— FOR LAST HALF OF 1924
DOTTED LINE - - - - FOR LAST HALF OF 1927
NUMBER OF OPERATORS IN PERCENT OF TOTAL IN GROUP
25
20
15
10
5
NOTE THE SHIFT TO RIGHT AND GENERAL IMPROVEMENT
THE AVERAGE HOURLY EARNINGS IN CENTS WERE NEARLY ONE THIRD HIGHER IN THE LATTER PERIOD THAN IN THE FORMER PERIOD
75-7 78-0 81-3 84-6 87-9 90-2 93-5 96-8 99-01 102# 105-7 108-10 111-13 114-6
RANKING OF OPERATORS
AVERAGE = 100
MANUFACTURED BY PAPER UTILITIES CO. PHILADELPHIA
20 LINES = 1 INCH

CHAPTER V

RATING WINDERS WITH REFERENCE TO QUALITY OF PRODUCTION

Interest centers not only in how much work is done by an operator, but also in how well the work is done. There are jobs in which it is impossible to determine the amount or proportion of unsatisfactory work which an operator turns out. A trucker for example, may never have a record of seconds. The quality of his work, nevertheless, is something which is certain to be given consideration. If he is continually bumping machines with his truck, and upsetting the goods which are on the truck, one would say that he is doing a poor quality of work. The importance of quality, however, varies according to the nature of the process.

Whatever the importance of quality of work in this winding operation, our study of individual production rating should include it. The first factor to be investigated is the amount of perfect work done; second, the amount of waste of raw material; and a third quality factor is care as applied to machinery, equipment and work place. There is one other matter that should always be considered, although it is ofttimes so intangible as to defy precise analysis. This last factor is the ability to handle the exceptionality. Let us see what records are available on the basis of which we may be able to make quality ratings of the winders with reference to the four factors just mentioned.

The lack of perfection in winding is reflected in part by the number of defective cones wound. A defective cone can be reconverted, but the work must be done again. The rewinding of the cone can be done easier than the first winding, but as it takes nearly as long to do the rewinding, the labor cost is almost doubled thereby. Rewinding requires an extra amount of machinery and equipment and retards the department in meeting production schedules. Not all imperfections of cones are due to faults of the operator so

the number of imperfect cones which could be used in individual quality rating would be limited to those caused by fault of the operator. Each of these mills files a general report which gives the total amount of reruns, but as yet they have not been listed as to the number of defective cones made by each operator. From the general report made by the mills, it appears that about 0.36% of the winding done in the mills in a year was rewound on account of the imperfect work of the operator. In the last ten weeks of the year the average was only 4-100 of one percent. (See the table below). It may not be advisable to entail the clerical work necessary to follow up the defective winding of each operator on account of the small amount of defective work and the small loss that it involves.

PERCENTAGE OF RERUNS IN WINDING DUE TO THE OPERATOR

First Half of Year					Second Half of Year			
Week Ending	Mill A	Mill B	Mill C	Mill D	Week Ending	Mill A	Mill B	Mill C
1-5	0.36	0.08	0.77		7-5	0.01		
1-12	0.57	0.12	0.07		7-12	0.02		
1-19	0.87	0.04	0.83		7-19			
1-26	0.80	0.15	0.95		7-26			
2-2	0.27	0.07	0.76		8-2	0.01		
2-9	0.39	0.10	0.77		8-9	0.01		
2-16	0.02	0.06	0.73		8-16			
2-23	0.01	0.14	0.74		8-23			
3-1	0.11	0.16	0.76	3.05	8-30			
3-8	0.07	0.10	0.60	5.88	9-6			0.03
3-15	0.10	0.08	0.60	2.60	9-13			0.04
3-22	0.11	0.07	0.42		9-20			0.03
3-29	0.11	0.05	0.25		9-27	0.03		
4-5	0.14	0.06	0.35	0.40	10-4	0.04		0.02
4-12	0.04	0.13	0.24	0.76	10-11	0.04		
4-19	0.10	0.06	0.15	0.64	10-18	0.01		
4-26	0.04	0.06	0.27	0.85	10-25			
5-3	0.06	0.04	0.21	0.81	11-1	0.03	0.01	
5-10	0.11	0.04	0.07	0.57	11-8	0.17	0.17	0.02
5-17	0.08		0.05	0.17	11-15	0.01		0.10
5-24			0.08		11-22	0.07		0.01
5-31			0.09	0.03	11-29	0.04		
6-7					12-6	0.11	0.08	0.07
6-14					12-13	0.07		0.06
6-21	0.02				12-20	0.06		0.07
6-28	0.01				12-27	0.01		

Average for the year, Mill A, 0.0986; Mill B, 0.0367; Mill C, 0.2001; Mill D, 1.126.

Mill D. was closed from the first of the year until the week of March 1st. The faulty work of new operators hired on the reopening of the mill is to be noted.

The amount of waste caused by the operator is a factor of great importance in some operations. The winders increase waste by using a large amount of yarn to tie knots. One operator wraps several turns of yarn about her hand to get the ends in a favorable position for tying the weaver's knot, whereas, another takes only one turn of the yarn around her fingers. One operator pulls more yarn off the bobbin in case of a tangle then would another. Waste yarn brings a very small price compared with that of the regular product. Figuring the loss occasioned by the waste of each operator in percentage of the earnings of the operator, is a good way to express this quality factor. In Mill C, the percentage of waste ranged from 3.49 to 7.79, the average being 5.41. In Mill D, the average was 5.2% with the low mark at 2.2%, and the high mark 11.6%. The other mills in this study have not as yet arranged to keep waste records for each operator. The tables, pages 59 and 61, list the operators in rank as to quantity of production, the highest produced being at the top of the list. The rank with respect to percentage of loss by waste is in the second column, the least waste being indicated by Rank 1.

If the operators making the highest amount of production were the ones who had the greatest amount of waste, one would conclude that an attempt to prevent waste retards production. Such is not the case, so effort to reduce waste does not necessarily impede the quantity of production.

Incidental to our study we find that effort to reduce waste was worthwhile. Mill C reduced the loss from waste (in percentage of earnings) from 5.41% in the second half of 1924 to 3.87% in the first half of 1925, thereby effecting a saving of over three hundred dollars in the six months period. If Mill C could bring the present average loss down to the percent of 2.67 which was the figure for one operator, a further saving of two hundred dollars would be made in six months.

As yet no mathematical measures have been used to indicate the ways the winders care for machinery and equipment, yet it might be possible to do so. Once a week or month, the foreman or supervisor could make an inspection of the way the operators were caring for machines and record notations which would lend themselves to mathematical averages. Such a plan would still be an opinion rating but it would be based upon a specific inspection rather than upon a general impression. A foreman may on some occasion observe that an operator has soiled hands and that there is waste yarn on her machine, and on such evidence conclude that the operator is an untidy worker. In case the foreman or supervisor inspects the machine and equipment periodically to make notations, there is greater likelihood of his making a correct observation and when the observations are recorded and averaged, the figure will bear a closer relationship to the actual facts. However, as previously stated, there is not a great deal of difference in the way operators care for the winding machines for there is little to get out of order and very little for the operator to do except oil the spindles and clean off the dust. Therefore, in this operation this phase of quality work is not important enough to be given the clerical attention that would make possible a systematic rating.

The other factor with reference to quality of work is the ability to handle unusual, special, or exceptional matters. Perhaps in no operation can such a factor be measured exactly. But a figure which bears a real relation to fact is worth more than an offhand opinion. So search should be made for some figure that will indicate the ability of the operator in this phase of quality work.

It happens that in the winding mills which record the amount of waste, five cents is paid the operator for every bobbin of defective yarn which she finds. The defective bobbins are rare or exceptional and yet occasionally an operator finds a bobbin with slack twist, hard twist or the wrong ply. The record of allowances or payments for

defective bobbins may then be counted as an indication of quality of work. The figure is not very useful for any one week as an operator may possibly find a large number of defective bobbins in a certain assignment, a number out of proportion to the usual averages. Over a long period, however, the average number of defective bobbins found per week bears closer relationship to ability to handle the exceptionality than would any other measure available.

The tables (pages 59 and 61) show the records for the two quality factors, amount of waste and number of defective bobbins found. As one may suppose, these factors are quite dissimilar. The one factor, waste, represents care in handling materials and deftness in movements. The other factor is a test of observation, of analytical discrimination.[1] It is natural to expect that there will be marked differences for the same operators between the quality work with respect to waste and with respect to finding defective bobbins. The tables on page 61 show a quality rating of operators giving equal importance to the factors. Then double importance is given the waste factor and a new rating is made. What the relative importance of these items should be, has not been decided in these mills.

[1]The matter of chance may affect the quality record in short periods on either of these phases. But the distribution of work as previously explained will offset these in long periods. The ratings are based on a six months' record which is long enough to distribute the chances evenly.

QUANTITY AND QUALITY OF INDIVIDUAL PRODUCTION

MILL C, LAST HALF 1924

	Earnings per hour % of Aver.	Total value of waste in percentage of earnings	Average No. of bad bobbins found per week
F. Blythe	115	3.81	6.36
G. Goldsborough	113	6.32	3.80
V. Silknitter	109	3.49	3.68
A. Kelley	109	6.57	2.33

L. Hulton	108	5.08	3.16
E. Ransome	108	4.40	7.32
G. ReDavid	108	5.51	3.70
E. Donovan	108	5.31	4.13
J. Debrony	107	4.91	4.12
H. Cocchi	106	5.16	4.48
F. Watkins	106	5.95	3.28
M. Dougherty	105	4.44	6.52
J. Devine	105	6.03	2.37
L. News	105	6.40	3.28
S. Lewis	105	4.20	4.56
A. Tull	105	4.76	4.38
M. Camana	104	4.35	1.54
M. Demarco	104	4.61	5.84
C. Howley	104	7.18	2.33
H. Bonsall	104	5.23	0.00
K. Warren	103	4.87	4.20
M. Richardson	103	4.51	4.48
V. Ardes	102	5.24	.72
S. Pas	102	7.79	2.76
D. Kimball	102	4.12	.96
C. Davis	101	4.63	1.36
E. Koppelmyer	101	4.78	4.56
M. McKenzie	101	6.08	2.21
M. Glennen	101	4.60	7.16
R. Smith	101	5.02	2.42
M. Kleo	100	5.10	1.72
P. Lutrelle	100	4.99	6.72
C. Ryder	100		.08
H. Anderson	100	4.90	3.00
B. McConomy	100	5.10	.92
M. Boyd	99	5.16	1.86
M. Atkins	99	5.58	.50
A. Thomas	98	5.10	.32
M. Ferguson	98	5.00	2.72
A. Masterson	98	5.28	3.20
J. Hadley	97	4.76	6.31
E. Heaps	97	6.42	3.12
A. Monaghan	97	5.21	1.08
E. Markley	96	6.66	4.76
L. Murphy	96	6.80	2.88
F. Boulden	96	4.91	4.52
M. Shelton	95	5.63	4.24
P. Miller	95	6.37	5.80
E. Jones	94	6.21	1.38
M. Cawley	90	6.30	4.56
J. Howelt	90	4.90	1.75
M. Davis	90	5.49	1.28
F. Green	89	5.64	.13
M. Boulden	88	5.01	7.45
M. Campbell	87	6.27	.40
E. W. Ransome	86	6.17	2.00
H. Clampitt	82	6.91	1.76
N. Devlin	81	7.09	2.06
AVERAGE	100	5.41	3.24

QUANTITY AND QUALITY RATINGS, MILL C, LAST HALF 1924

I. Quantity Rank	II. Waste Rank	III. Bad Bobbins Discovered Rank	IV. Adding Columns 2 and 3	V. Quality Rank (Col. IV)	VI. Weighted Total	VII. Quality Rank (Col. VI)	VIII. Opinion Foreman's Regarding Quality
1	2	6	8	A	10	A	A
2	42	18	60	C	102	C	A
3	1	20	21	A	22	A	A
4	46	31	77	C	123	C	A
5	20	23	43	B	63	B	A
6	6	2	8	A	14	A	A
6	29	19	48	B	77	B	B
7	27	16	43	B	70	B	A
8	16	17	33	A	49	A	B
9	22	13	35	B	57	B	B
10	35	21	56	B	91	B	A
11	7	5	12	A	19	A	A
11	36	30	66	C	102	C	A
11	44	21	65	C	109	C	A
12	4	11	15	A	19	A	A
13	12	14	26	A	38	A	A
14	5	38	43	B	48	A	B
14	10	8	18	A	28	A	A
15	51	31	82	C	133	D	A
16	24						A
17	14	15	29	A	43	A	A
18	8	13	21	A	29	A	B
19	25	44	69	C	94	C	A
20	52	27	79	C	131	C	A
21	3	43	46	B	49	A	A
22	11	40	51	B	62	B	A
22	13	11	24	A	37	A	A
23	37	32	69	C	106	C	B
23	9	3	12	A	21	A	A
24	19	29	48	B	67	B	B
25	21	37	58	C	79	B	A
25	17	4	21	A	38	A	A
26		49					A
27	15	25	40	B	55	B	A
27	21	43	64	C	85	B	B
28	22	35	57	B	79	B	B
29	30	45	75	C	105	C	B
30	21	47	68	C	89	B	B
31	17	28	45	B	62	B	A
31	26	22	48	B	74	B	A
32	12	7	19	A	31	A	B
32	45	24	69	C	114	C	B
33	23	42	65	C	88	B	A
34	47	10	57	B	84	B	B
34	48	26	74	C	122	C	A
34	16	12	28	A	44	A	A

35	33	14	47	B	80	B	B
36	43	9	52	B	95	C	B
37	39	39	78	A	117	C	A
38	41	11	52	B	93	C	B
38	15	37	52	B	67	B	A
39	28	41	69	C	97	C	B
40	34	48	82	C	116	C	B
41	18	1	19	A	37	A	A
42	40	46	86	D	128	C	B
43	38	34	72	B	110	C	A
44	49	36	85	D	147	D	A
45	50	33	83	C	150	D	A

x Giving double importance to waste as compared with bad bobbins found.

Column 2 multiplied by 2, added to column 3

BASIS OF CLASSIFICATIONS

	Column 5	Column 7
A	8 to 33	10 to 50
B	34 to 58	51 to 91
C	59 to 83	92 to 131
D	84 up	132 up

AGREEMENTS BETWEEN FACTUAL RATING AND FOREMAN'S OPINION OF QUALITY OF INDIVIDUAL PRODUCTION

Mill C, Second Half 1924

Ratings when Factors of Waste and Finding Bad Bobbins are given Equal Importance

	Factual Rating	Foreman's Opinion	No. of Agreements
Class A	16	36	13
Class B	19	20	9
Class C	19	0	0
Class D	2	0	0
	56	56	22 or 39.3%

Ratings when Factor of Waste is given Twice the importance of Finding Bad Bobbins

	Factual Rating	Foreman's Opinion	No. of Agreements
Class A	18	36	14
Class B	18	20	8
Class C	17	0	0
Class D	3	0	0
	56	56	22 or 39.3%

AGREEMENTS BETWEEN FACTUAL RATINGS AND FOREMAN'S OPINION OF QUALITY OF INDIVIDUAL PRODUCTION

Mill D, Second half 1925

Ratings when Factors of Waste and Finding Bad Bobbins are given equal importance

	Factual Rating	Foreman's Opinion	No. of Agreements
Class A	14	64	14
Class B	39	8	3
Class C	17	0	0
Class D	2	0	0
TOTAL	72	72	17 or 23.6%

Ratings when Factor of Waste is Given Twice the Importance of Finding Bad Bobbins

	Factual Rating	Foreman's Opinion	No. of Agreements
Class A	19	64	18
Class B	36	8	3
Class C	15	0	0
Class D	2	0	0
TOTAL	72	72	21 or 29.6%

As may be noted, Relative Rating has been used with reference to quality of winding.[1]. The reasons for the selection of this type of rating are the same as for quantity rating. Necessarily some waste yarn is made in the operation; the standard procedure cannot be followed without having a bit of waste yarn left after tying a knot. An Absolute Rating may be made of the waste factor although admitting no operator could attain a hundred percent under such a type of rating. In the weaving operation where it is possible for the weaver to make no seconds in months and where the waste factor may be the only one of importance as in making plain goods, Absolute Rating is apparently the best type of quality rating. However,

[1]The grouping of the operators into classes as to quality has been done in a way somewhat similar to quantity of productive output. The total number of passable operators was divided into three equal areas according to points in their quality factors. This places approximately one-fourth, one-half, and one-fourth of the operators in each rank, A, B, and C respectively.

when the waste factor is combined with that of handling exceptional matters, Absolute Rating is unsuitable. The question presents itself; what would be one-hundred percent perfect in finding defective bobbins? The obvious answer is, to find all the defective bobbins that come to an operator's machine. But how can it be determined how many defective bobbins there are in each assignment? Standard Rating may be used provided there are sufficient and satisfactory records of experience on which to base the standard. The change in average waste value from 5.41% of earnings in one period to 3.87% six months later, indicates a general improvement. A standard of tolerance for the number of defective bobbins in a week would be poor practice, as lots of yarn are somewhat irregular in quality. The period of recorded experience in these mills is too short to admit of proper standards with reference to quality. The nature of the operation is such that it seems well to base quality rating on the two factors, neither of which have been completely standardized and in neither can perfection of performance be definitely determined. The conditions are changing owing to increased supervision and training. It would seem advisable to continue the record of finding defective bobbins due to the importance of encouraging their removal. Although it is not sufficiently comprehensive nor entirely accurate, the relative rating of quality as herein developed, is of practical value and points the way to better standards of workmanship.

A comparison of factual ratings and foreman's opinion regarding quality of work, reveals the same general characteristics as the comparison with regard to quantity of production. The foreman has the impression that one-half or more of the operators in the department do first class quality work. Such proficiency is possible. But from an examination of the range in quality work, it seems that no violence is done to the operators who are listed as third class. Of course a mere relative ranking results in a third class group, regardless of how closely they approximate

the work of those in the average group or the superior group. In Mill C however, the operators in the third class with respect to quality made an average of one-sixth more waste than the average of the entire department; and they made two-fifths more waste than the average of the first class operators. It is to be noted that one operator had 3.49% waste, another 7.79%, or over twice as much. With respect to defective bobbins found, a still greater difference is noted between the highest and the lowest record. One operator averaged .72 a week and another 7.32. or ten times as many. If the difference between the lowest and the highest were very slight, the foreman might be quite right in rating all operators as good or average. But these differences between the lowest and the highest are great enough to justify the C class ratings. A comparison of facts with the foreman's impressions regarding quality shows that the foreman fails to see the strategic opportunities to improve the inferior operators because he does not know which operators need special attention.

CHAPTER VI

APPLICATION OF INDIVIDUAL PRODUCTION RATING TO WEAVERS

The general method of production rating for winders, weavers, or for any other industrial operatives will be the same if properly done. The way in which to apply the method previously described is again exemplified in this chapter in the steps taken to rate weavers. Briefly they are:

1. Job study.
2. Examination of the variables in the job to determine,
   a. if the variables constitute or result in large differences in job assignments.
   b. if the large number of assignments in a given period of time tend to cancel out small differences,
   c. if there are other tendencies to cancel out the differences such as even distribution of work.
   d. standard allowance to be made for each variable.
3. Study of records available or necessary to furnish satisfactory bases of rating:
   a. does the payroll constitute a valid and sufficient basis for rating operatives?
   b. what other records are needed to supplement payroll records?
4. Selection of a type of rating most satisfactory to start with, either Relative or Absolute, and the establishment of lines of approach to the final objective—Standard rating as a permanent type.
   a. New records that will be necessary
   b. How the records are best compiled
   c. How the records are used in individual production rating
   d. Other important ends that may be served by record keeping.

The weaving operation is found to be subject to variables not found in the winding operation and in the beginning the Absolute type of rating is more suitable, whereas the Relative type was best in introducing the rating of winders. In any case the Standard type of rating will be used when the accumulated data affords a satisfactory basis for its use.

Conditions different from those of the winding department prevail in the weave rooms where individual production rating is being developed. Each winding operator handles the same number of spindles, running them in

practically the same way and on the same material as other operators; but each weaver's job is slightly different from that of every other weaver. The loom is vastly different from a winding frame and the operator of a loom has much more machine manipulation and control to perform than has the operator of a winding machine.

At the beginning of the job study let us look carefully at the loom and the weaving process. A loom is designed on a very simple principle. It is a machine which interlaces threads so as to form cloth. The piece of cloth may be woven in any length up to fifteen hundred yards, but in the weaving mill of this study the width is limited by the build of the machine to forty-two inches.

The looms hold all the lengthwise threads called the warp on a roller at the back of the frame and these threads are pulled across the loom to a roller in the front on which is wound the woven cloth. The roller at the back is shaped like a long but large spool and is called a warp beam. The cloth beam and the warp beam are both horizontal to the floor. As many threads as are desired in the warp are wound flat upon the warp beam, as though the threads had formed a ribbon about the same width that the cloth is going to be. Each thread, on its way to the front of the loom passes through one of the eyelets in the harness frame. The harness are made up of many frames on which are vertical wires. In the middle of each wire is an eyelet for holding a warp thread. A mechanism in the loom operates these harnesses so as to lift certain frames and at the same time lower all the other frames. In the simplest weaving operation the loom lifts every other thread by the eyelets mentioned. This opens up an angular space called a shed between the raised threads and those that are lowered. A shuttle is thrown across in this opening leaving a trail of thread-filling at right angles to the warp, and lying between the raised and lowered warp threads. This filling is called the weft or the filling in the cloth. Each thread thus laid in is called a pick. The shuttle contains a bobbin from which the yarn runs loosely

through an eyelet at one end. The shuttle is thrown through the shed by a "picking motion," and it rests briefly in a box at either end of the loom while the lay pushes the last filling thread up firmly into place against the threads crossed just in front of the previous filling thread.

The lay makes the weaving compact and regular. The main feature of the lay is a set of thin wooden or metal reeds between which pass the warp threads. As the reeds are several inches high, it swings up against the filling without interfering with the up and down movement of the warp threads. As soon as the lay starts to swing up against the pick of filling, the harnesses are set in motion again. In the simplest weaving formation the threads which were on top of the pick of filling just placed in the fabric are lowered and all the other threads are raised. A new shed is thus formed for the next pick. This crossing of the warp threads after each pick of filling binds the threads together so as to form cloth.

As the fabric is woven it is wound automatically around the cloth beam. Usually there are marks on the unwoven warp at given intervals, twenty-five, fifty, or seventy-five yards apart, and when these marked places have reached the cloth beam with enough over to start winding on a new cloth beam, the weaver cuts the cloth off at that mark, removes the cloth and the cloth beam on which it is wound, and starts the oncoming cloth winding around a new beam. In some mills, the weaver merely cuts the cloth at that point, removes the long piece thus cut off, and then starts the cloth winding around the same beam again. The length of cloth thus cut off is called a "cut". The cloth beam is so adjusted that it turns slowly and takes up, by winding steadily, one inch of cloth for every certain number of picks of the loom. Thus if the loom is set to make 60 picks per inch, the take-up motion will pull gradually till one inch of the warp of the fabric comes across the loom while the loom is picking sixty times.

Variety of pattern is brought about by several means. A common way is to have more than one shuttle, with a dif-

ferent kind or color of yarn in each shuttle. The shuttles are then alternated in certain sequences and frequencies. In such alternations one shuttle may be used for a large number of picks in succession and then each of the other shuttles used for a few picks each; or the pattern may call for an equal number of picks from each; again the pattern may be designed to require colors in some recurring frequencies such as the ratios, 2, 4, 6, and 8 picks from respective shuttles. Another method of weaving a pattern is to have the various colors of warp threads in groupings that give a stripe effect in the design. The pattern is affected also by the action of the harness. The simplest weave formation was mentioned above. Complexities of pattern are added by variations in the number of threads lifted each time, and in the sequences, frequencies, and grouping of the alternate raising and lowering of the warp threads. These alternations, worked in combination with the filling variations, give an almost unlimited possibility for results.

Looms are all of the same general type, but vary considerably in speed. The speed of looms is figured in terms of picks per minute. The difference in the speeds of the looms has a marked effect upon output as one may suppose. When two identical fabrics are weaving side by side, one on a loom which runs at one hundred picks per minute and the other on a loom which runs at one hundred twenty picks per minute, there is a possibility of twenty percent faster production on the latter. An offsetting possibility is that, for the kind of fabric being woven, the higher speed might cause greater difficulty in weaving, and of such a nature that the delays incident thereto might more than offset the increased speed of the loom. This point will be raised again in connection with the rating plan for weavers.

Loom construction has been steadily improved so that now there are many special features. Among these new attachments is an automatic stop motion which will stop the loom when a warp thread breaks. There is a mech-

anism to stop the loom whenever the filling breaks, or when the filling has been all used in the shuttle. Certain parts for a loom can be secured which give great variety in pattern weaving. Additional boxes enable the weaving of a fabric using several different kinds of filling in given arrangement of design. Regularity of width of cloth, evenness in picks per inch, regularity of design, evenness in tension on all threads in the warp, and many other quality features are secured in the newer types of looms.

A break of any one of the hundreds of the warp threads necessitates extra work for the weaver and a delay in the loom operation. Breaks may be caused by a number of things. The up and down movements of the harness cause a strain on the warp threads due to tension, as well as a wearing on the yarn from rubbing as the harnesses rub against it in changing position. This double strain on the yarn is certain to result in a breakage of one or more threads from time to time. Sometimes a slightly rough place on the shuttle will rub against one or more warp threads and break them out. Sometimes a little lint will settle on the warp yarn and as the threads are moved up and down, the lint will be intertwined with two or more threads until they cannot be easily pulled apart. When this tangled condition comes up to the harness, the pulling of one of the threads to a position above the filling and the lowering of the other away from it results in a break. Warp threads may break from various other causes such as weakness in the fibres of the yarn, imperfect spinning of the yarn, unsatisfactory humidification in the air, improper sizing, or previous injury to the yarn. Whatever the cause, the operator's task is to repair the broken place.

When the warp thread breaks, the weaver must take a piece of tie-up yarn which is the same kind and color of yarn as the one just broken and tie the new piece to the loose end which comes from the warp beam. The tie-up piece must then be drawn through the harness and through the proper place in the reed, and then held with the proper tension while the loom is started and the weav-

ing goes far enough to hold the new piece of yarn in its proper place. This part of a weaver's job is called "tying up broken ends."

Replenishing the filling and taking care of filling difficulties is another task of the weaver. A break in the filling or weft yarn entails extra work and a loom delay. A break may be due to a little roughness of the eyelet in the shuttle or it may be due to the yarn catching or binding as it is being unwound from the bobbin or cop within the shuttle. Of course the filling yarn in a shuttle runs out after a time, and then it is necessary to remove the empty bobbin from the shuttle and to put in a full bobbin. On some looms an automatic contrivance does this just as the shuttle pauses for an instant at the end of its trip across the warp and before it returns. On other looms the filling must be changed by hand, each time the bobbin becomes empty. These changes require much of a weaver's time and so it is impossible for him to run so many looms if he has looms without the automatic filling-changing devices. In these days nearly all the looms are equipped with filling stop motions, so that the looms stop when the filling is not being laid in by the shuttles, due either to a breakage or to having run out. A weaver's task is to get the loom running properly again and to get the weaving to continue regularly as to pattern from the point last woven. If the loom should make one or two movements after the filling has run out, or broken,—and it is possible that the stop motion should not operate properly on all occasions—the weaver must set back the pattern chain so that the weaving will continue the pattern correctly.

The weaver may discover that some flaw in weaving has been made in the last few picks prior to the loom stopping. The weaver in such case, takes a little comb or brush to remove the last few defective picks from the cloth. He then lets the take-up motion back as many notches as necessary to compensate for the picks removed, pulls the warp back on the beam, and sets the pattern chain back so that these picks will be woven into the pat-

tern. This part of the weaver's task also requires training and experience.

Besides taking care of any yarn difficulties in weaving, the weaver must note if the loom fails to operate properly. Such failures may be caused by any of a considerable number of ill adjustments of the loom mechanisms. Usually the loom fixer is called. The weaver is held responsible unless he tells the loom fixer of this need of adjustment or repair. It may be mentioned that with so many parts and intricate mechanisms, and all working at high rates of speed, there are very frequent needs for the attention of the loom fixer. Usually however, one loom fixer can care for as many looms as four to eight weavers can handle.

From the description of the weaving operation one would rightly assume that it takes considerable time and experience to become a good weaver. Although the principle of the loom is simple, it is really a complex apparatus and the weaver must be able to operate it as a machine. More than that, the weaver must have a skillful hand so that he can pick up any broken one of a possible two thousand threads that may be running parallel in a warp less than a yard wide, and tie up the broken ends. Experience is needed to find out which harness is the one through which to bring the tied-up end and then to bring the end through the proper eyelet, and through the proper place in the lay. The readjustment of the loom to make the proper pattern after each stop is one of the most difficult parts of the weaving operation. Other facts enter into technique but they would require too much time and space to mention. However, a good weaver has usually spent three to five years in acquiring his skill.

In the cheaper fabrics, the emphasis in weaving is placed upon the quantity of cloth produced by the weaver. In the more costly fabrics, the emphasis is shifted to the quality of the cloth produced. This is true because there is more criticism of quality features when purchasers are buying expensive materials and if the material is rejected because of poor quality, the loss to the manufacturer would

be much greater in the case of the costly fabric than in the case of the cheaper one. Another factor is that the cost of the weaver's wages forms a relatively lower share of the total cost of the fabric. It is not possible for a manufacturer to reclaim yarn from a woven fabric, with a view to reweaving the cloth. The cloth cannot be converted into some other fabric unless it be used in a rag rug or some cheap article of that kind. If the defects are not too serious, the cloth will find a market as a second grade fabric usually referred to as a "second". Seconds are far below the firsts in point of price.[1]

Up to this point we have been considering the general subject of weaving. Let us turn now to the particular variables in the weaving mill where individual production rating is being introduced. The variables which are listed below will be discussed in the following paragraphs:

a. Number of looms in a weaver's stand.
b. Difference in the looms—automatic or hand changing of filling, width of loom, harness capacity, number of boxes, speeds.
c. Kinds of fabrics and styles of cloth, length of warps.

The group of looms which a weaver operates is called a stand. He may have a stand of four looms, of five, or of six looms which have no automatic filling changing device. Ten automatic looms are assigned for a stand. The automatic loom changes the shuttle or bobbin when additional filling is required without the attention of the weaver except to load the magazine at his convenience, and of course it is done without any stoppage of the loom.

Some looms weave cloth a few inches wider than others, but the small difference in width does not slacken the speed of the looms noticeably although the wider fabrics use up the filling more rapidly than the narrow ones.

All of the looms have dobby head motions which make possible the weaving of rather intricate patterns. Some looms have capacity for sixteen harnesses, some for

[1]It has been stated that in many mills, when a weaver makes a second of a cut of cloth, the mill's profit on four other cuts is lost. Moller, Kenneth, Director of Lockwood, Green and Co. Textile World, January 12, 1924.

twenty-four, and others for thirty harnesses. Some of them are single box looms and all the others are four or six box looms. Not all the patterns woven on the latter looms require the use of all of the boxes. A box on a loom holds a shuttle, and four boxes enables the loom to use four different shuttles and thus to weave cloth having four different kinds or colors of filling. More skill is required to operate a multiple-box loom than a single-box loom. The skill is required on such occasions as starting the loom. When a loom stops there is a likelihood that a picking motion has been incompleted, or that one or more imperfect picks in the cloth must be removed, and in starting up with multiple boxes, the weaver must exercise special knowledge and care to set the pattern chain so as to operate the boxes properly. If an operator is weaving a plain fabric on a four box loom, the loom is usually set to use only one box and the operation is then the same as if the loom had but a single box. In other words, the fabric and style of the goods being woven determine the skill and work required in weaving rather than the harness or box capacity of the loom; on the other hand, the loom capacity limits the weaving possibilities and is likely to limit somewhat the skill and care required.

The speeds of looms present some interesting anomalies. Loom speeds in this weave room vary in ratio from one hundred to one hundred twenty-one picks per minute, but the speed of any one loom is fairly constant. The variation in any one loom is ordinarily due to a change in belts or to belt conditions. A new belt will stretch and as it does so, the loom speed will decrease. The loom-fixer will shorten the belt and then the speed of the loom will be greater for a time, but gradually slacken as the belt stretches. Perhaps it will be necessary to shorten a belt two or three times before the belt reaches a fairly constant length. A leather belt will vary in length according to the amount of humidity in the atmosphere, and sometimes the dampness of the atmosphere seems to affect the surface of the belt so that it grips the pulley better. With few

exceptions the belting material throughout the room is uniform, and a leather belt will last several years. An effort is made to keep the air of the room at a certain temperature with a certain relative humidity. The minor changes in humidity affect the room as a whole rather than any one section. The speed of the loom may be changed by changing the pulley on the driving shaft, but this is done only in special instances, not as a frequent or regular practice.

Beyond a given point for each fabric and loom no time is saved by increasing the speed of the loom. In fact a considerable increase in loom speed beyond the given point would cause a loss in weaving time or result in defective cloth because the faster picking motion of the loom places sudden strains upon the yarn and causes breakage and defects which more than offset the gains made by faster speed.

The fabrics woven in this mill are of a considerable variety. Some are made of heavy cotton yarn in both warp and filling. Others are made of finer cotton yarn with fancier patterns. Flannels are made of cotton warps with fine worsted filling. Some novelty fabrics are made with cotton warps and with some rayon filling. Any of these fabrics except the flannels may be made with patterns in checks or stripes. In some of the finer fabrics novelty yarn may be used either to make a stripe or to set off the pattern by forming the border where there is a change of color. Still another arrangement is weaving a special design in spots, making the spots appear as though they were embroidered.

An examination of these variables leads to the conclusion that the many differences between weaving jobs do not cancel out in a short period of time as was the case in the winding operation. The long period required to attain skill in the weaving operation attests to the multiplicity of difficulties and conditions which a weaver will meet. Various percentages added to the basic piece rate are intended as fair compensation for the variables en-

countered. As shall presently appear, these percentages cumulatively amount to over thirty-seven percent, therefore one may confidently assume that the differences are large enough to be important. The differences in the construction and speed of the looms precludes the possibility of even distribution of work. As a weaver spends from six to nine weeks on each warp and has only four, five, or six warps at a time (unless running automatic looms) he does not have enough job assignments in a short period of time to cancel out such large differences. Therefore, the variables described must be kept in mind and accounted for in any rating plan undertaken.

Let us now turn to find what production records are available. The payroll is the one to which recourse would first be made in studying performance of piece workers. A study of the pay schedule will throw more light on variables encountered by the weavers.

A weaver is paid for each cut of cloth woven on a loom operated by him. The pay per cut varies according to the kind of loom and the nature of the fabric being woven. A table on the following page lists these variables which enter into the setting of rates, and gives the amount of difference in pay which is now based upon them. The base rate is figured on picks per inch in the cloth to be woven, and the rate as a ratio is two and one half cents per pick per inch. The unit paid for is a cut of cloth. No change is made in the base rate for either fast or slow looms. The other factors which are taken into consideration and for which allowances are made, are discussed in the order in which they are applied to the base rate. (See table, "Schedule of Piece Rates for Weavers.")

An addition is made to the basic piece rate if special yarn is used in the filling because the special yarn will involve extra trouble or delays in weaving. Usually the special yarns necessitate having the shuttle lined inside with some material such a wool or fur so as to provide the proper tension. The weaver is delayed while the loom fixer is lining the shuttles and testing the results of his

SCHEDULE OF PIECE RATES FOR WEAVERS

Picks per inch in cloth	Pay per cut Base Rate Ratio	Additions to Base Rates: Loom Speed	Material in Filling	Number of Ends in Warp	Material in Warp	Harnesses required in style	Loom boxes
40	$1.00	No allowance made for differences	Add 3% if half of filling is special yarn Add 6% if all of filling is special yarn	If warp has over 1200 ends, add 5%	Add 5% if half of warp is special yarn Add 10% if all of warp is special yarn or if considerable portion is of super-special yarn	Add nothing if less than 16 harnesses are used Add 4% if 16 to 20 harnesses are used Add 8% if 21 to 30 harnesses are used	If the loom has more than one box add 5% to the last total rate. If the loom has automatic filling-changing device, deduct 40%
42	1.05						
44	1.10						
46	1.15						
48	1.20						
50	1.25						
52	1.30						
54	1.35						
56	1.40						
58	1.45						
60	1.50						
62	1.55						
64	1.60						
66	1.65						
68	1.70						
70	1.75						
72	1.80						
74	1.85						
76	1.90						
78	1.95						

Note 1. The base rate is not the exact payment per cut but conforms to the actual schedule as a table of ratios.

Note 2. The additions above are cumulative, each one being added to the last sum of base rate plus previous additions. For example, the rate on a weaving job of forty picks per inch, all special filling, having thirteen hundreds ends in a warp of special yarn, using thirty harnesses and two boxes would be figured as follows:

$1.00 plus 6% plus 5% plus 10% plus 8% plus 5% equals $1.38

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workmanship. The special yarn is more likely to break than the ordinary filling and so there is the probability that there will be more loom stoppages of that character. The addition of three and six percent respectively for half or all special material in filling, is an attempt to compensate for the extra care and delays involved, but until or unless the weaving time of the various fabrics are listed and studied with that factor in mind, the addition so made is merely an estimate rather than an accurate compensa-

tion. The same general statement holds true regarding all of the other additions listed. They are only estimates unless they have been verified by actual experience tables which make possible the accurate calculation of the effect on production of every variable and combination of variables.

The allowance of five percent for warps having over twelve hundred ends is made because the larger number of ends increases the number of thread breakages in warps. The increase is due to the fact that breakage is likely to occur in a percentage ratio, other factors being equal, so that the warp with many ends will have many breaks. A large number of ends crowds the harness so closely that the yarn is rubbed or chafed more than in a warp of fewer ends. The chafing augments the percentage of ends broken. If the warp has over twelve hundred ends, five percent is added to the sum of the base rate plus any addition made for special yarn in filling.

Special yarn in the warp requires extra care and entails delays. The yarn, being special, generally reacts differently to the tension which best suits the regular yarn. It is either looser or more elastic allowing drop wires to stop the loom, or it is less elastic and breaks occasionally on account of the strain upon it. Sometimes the special yarn is wound upon an extra beam and the tension of that beam can be adjusted without changing the tension on the regular beam. It necessitates the weaver taking care of another beam. Occasionally the special yarn in the warp is a novelty yarn not quite as strong as the regular warp yarn. Sometimes it is a novelty yarn with little lumps, flakes, or twists in it, and these enlarged places are apt to catch in the drop wires or harnesses and become broken; or they may rub against the regular yarn enough to chafe it. If half the warp is of special yarn, five percent is added to the sum of the base rate plus any additions for material in the filling and for the number of ends in the warp. Ten percent is added if the warp is composed of all special yarn.

Nothing is added if the style being woven requires less than sixteen harnesses. If sixteen to twenty harnesses are required, four percent is added to the sum of the base rate plus all previous additions. If twenty-one to thirty harnesses are used, eight percent is added. The use of a large number of harnesses increases the friction against the yard. It also adds to the strain due to the greater stretch of making a full sized shed and extending some distance back through a thick set of harnesses befocer coming back to the straight line level. Thread breakage and consequent work and delay result from the increased friction and tension strains upon the yarn.

To the last total rate per cut for weaving, five percent is added if the loom has more than one box, because the use of more than one box necessitates extra loom attention and adjustments. Each box must be kept in perfect adjustment to its shuttle and the mechanism controlling the box motion must be set for the various changes of filling called for by the pattern or style. Each shuttle must be observed closely by the weaver to make sure that the tension inside the shuttle releases the yarn evenly and with the proper drag upon the yarn. Careful watch must be kept for any rough places on the outside of the shuttle which would cut or damage the warp yarn through which it passes. A rough place on the shuttle might catch upon the yarn in such a way as to tear out a large portion of the warp; such smashes as they are called, involve quite a long delay before all the warp ends are properly tied in, ready to start weaving again. The weaver must also note whether the shuttle is being thrown across the loom with the right amount of force and speed so as to enter the receiving box directly and reach the right position for the next throw across the loom. Unless the loom is automatic it is also necessary for the weaver to note when the shuttle requires additional filling. Best weaving results are obtained by replenishing the shuttle just before the loom makes its last pick with the filling. The stop motion

does not always operate on the last pick of filling, and sometimes the thread goes only part way across the loom. Unless the weaver is watching and is ready to change the filling before this happens, some time is required to remove the last imperfect pick, to find the proper pick on which to start the loom again, and then set the pattern chain in order to start the loom properly. More than one box means that more than one shuttle may be used with the consequent extra burden of care and work for the weaver. This explains the additional piece rate for the multiple box looms.

The payroll department makes up the pay for the cloth cut from the looms but does not take into account the amount of cloth which remains on the looms because the cut marks have not been reached. Some irregularity in the amount of pay occurs when the weaver has left in the loom a length of cloth greater or less than the normal or average quantity. If at the end of the week he has over forty yards of cloth woven on each loom, whereas at the end of the following week he has only four or five yards of woven cloth left on each loom, the weaver would be paid more nearly in full than ordinarily. An average amount of woven cloth left on each loom is about thirty-five yards. The only time that an estimate of the length of cloth remaining on the loom is desired by the payroll clerk is when the weaver is leaving the employment of the company. Then the supervisor turns in an estimate of the cloth left on the looms, so that the weaver may be paid in full for the work done.

As the weaver is paid by piece rate, the payroll books do not show the number of hours worked each week by the weaver. The working time of each operative is shown on the individual's time card, but the records are not transcribed on the payroll sheets as they are not required in calculating the weaver's earnings. The records of hours worked are readily accessible and would be transcribed to the payroll records or to individual production record cards, as in the case of winders, if ratings of weavers are

to be based upon piece rate earnings.

If the average hourly earnings are used as the basis for rating weavers as for rating winders, the four loom weavers are grouped together for the purpose of comparison; the five loom weavers form another group, and the six loom weavers make still a third group. The automatic weavers constitute another group. A comparison of six loom weavers on the basis of piece rate earnings is made to show the simplicity of the procedure. The earnings listed in ratio run from eighty-one to one hundred thirteen. Considering the low stragglers as D class and dividing the remainder into three groups we have the following:

Earnings		to 86	— D class	number of weavers	2
Earnings	87 to 95	— C class	number of weavers	13
Earnings	96 to 104	— B class	number of weavers	25
Earnings	105 to 113	— A class	number of weavers	15

The quality rating can usually be cared for by records from the pay roll. The summation of fines for bad work in a given period gives a basis for quality rating. Fines for imperfect or unsatisfactory work are not permissible by law in some states. Circumventing the law, some manufacturers have adopted the plan of paying a certain wage schedule for weaving with the provision that ten percent or some similar proportion will be added for first class work. In other words there are two wage schedules—one for first class work and one for second class weaving. In such a wage system, the quality of the weaving may be readily determined, and such records will serve as a basis for a quality rating. If there is no difference in pay for the weaving of first and second quality cloth, then some extra notations are necessary in order to collect the data needed for quality rating.

Inequalities in piece rate schedules must be given attention. Unless all variations in the rates are based upon accurate calculations of known effects of all the variables in the jobs, inequalities are certain to exist. Whenever they do not exist and are not cancelled out by some circum-

stance such as numerous job assignments and even distribution of work, it is impossible to make a fair comparison of piece workers on the basis of earnings. It is also impossible to determine how nearly an operator is attaining perfect production. So neither Relative nor Absolute rating can be correctly done on the basis of piece rate earnings if the piece rates have not been scientifically adjusted.

As the piece rates in this weaving mill were set by estimates rather than by accurate calculations of known effects, it is advisable to verify the correctness of the piece rates or establish some other basis for rating weavers.

Three practical purposes will be served by establishing a rating basis other than piece rate earnings. Facts will be secured for rating the production of weavers more accurately; the schedule of piece rates will be verified or corrected; and data will be collected which is needed to establish weaving standards as to quantity and quality for each kind of loom and fabric. How these purposes are served will become apparent as the new basis for rating weavers is developed.

Quantity in either winding or weaving involves a time element. The treatment of time as a factor differs in the two cases. A large number of winding jobs can be completed during a week, so they are grouped together in total time worked, and the total of jobs completed is represented by the total piece rate earnings. Because of numerous assignments of similar jobs, the time and pay for any particular winding job is of small consequence in either total hours worked or in total weekly earnings. On the other hand, the weaver must take six to nine weeks to complete the weaving of each warp, and the weaving time of each job is thus of considerable consequence in the accurate rating of a weaver. Not many calculations or records are required to make a time rating on each job. The theoretically perfect weaving time for each warp can readily be computed. The actual time taken is then compared with the theoretically perfect weaving time and a ratio or percentage of efficiency is found. Therefore, WEAVING

EFFICIENCY rather than piece rate earnings will now become the basis for rating weavers.

Weaving efficiency, to be used as a basis for rating, requires first of all computations of the theoretically perfect weaving time. This theoretically perfect time is the criterion for evaluating the actual weaving time for any warp or fabric. Theoretical time is the abbreviated term hereafter used to refer to this perfect weaving time. It is the time required to weave a warp of given length, having a given number of picks per inch, on a loom making a given number of picks per minute, and with no allowance made for stops or interruptions of any kind during the working hours. It is, of course, impossible to weave a warp in the theoretical time. Unless looms are automatic in replacing the filling bobbins, or shuttles, a stop and delay of several seconds occurs every time a bobbin runs out of filling, which is about every yard of woven goods. This and many other causes for delays were discussed earlier in the chapter.

A sample of a way to assemble the data needed to compute theoretical time and make the ratings therefrom is the next step in the study. The loom number for the purpose of identification and its speed would be the first items of information to record. Then in other columns the following items should be listed:

Fabric
Length of warp or the number of cuts in it
Picks per inch in the fabric
Date and hour when the warp is started
Date and hour when the warp is completed
Actual loom hours taken
Theoretical time required
Weaving efficiency—Theoretical time divided by actual time
Cuts of cloth which are imperfect and reasons for being woven imperfect
Quality rating

A sample calculation will illustrate the way the ratio or weaving efficiency is found. If a weaver completes a warp of twelve hundred yards in four hundred and fifty working hours, during which time in uninterrupted weaving the weaver would have woven fifteen hundred yards,

theoretically perfect production would be twelve fifteenths, which is eighty percent efficiency. The same idea of lost time is conveyed by the statement that twenty percent of the time that the warp was in the loom was taken up with delays of various kinds. If one of the twenty cuts of the warp was a second, the percentage of seconds was five percent. The weaver's rating for any period is made up of the average of the efficiencies on all warps completed in the period.

In making the calculations of weaving efficiencies, it is well to remember that the theoretical time required to weave a warp having a certain number of picks in it, is figured with reference to the speed of the loom on which the warp is weaving. The speed of the loom is not considered in the payroll schedules for a weaver is paid a certain amount for weaving a cut of a certain fabric with no allowance made as to the loom being slow or fast. There are of course, some reasons why the pay schedules do not make such discriminations. One reason is that the weavers do not take the care to keep the loom up to the most rapid pickage desirable unless it is to his advantage to do so. A better, and perhaps the conclusive reason, is that it is not practical to have a large number of rates in a pay schedule if avoidable. The multiplicity of rates leads to confusion, increases the clerical work and augments the likelihood of error. The use of loom speeds as a basis for calculating theoretical weaving time is not troublesome. Formulas for each fabric can be prepared.

To work out a formula for figuring the efficienicy on a weaving job will be the next interesting step. The output will, of course, be a fractional part of what would theoretically be possible to weave in the given period of time. This fraction is found by the following calculations:

$$\frac{\text{Number of picks actually woven}}{\text{Number of picks theoretically possible to weave in that time}} \quad \text{(divided by)} \quad \text{or}$$

$$\frac{\text{Yards woven X 36 (inches per yard) X PPI}}{\text{Number of hours weaving X 60 (Minutes per hr.) X PPM}}$$

PPI is picks per inch in fabric woven PPM is picks per minute

Picks per minute is the speed of the loom, and this figure multiplied by the number of minutes the loom is operated, tells the total number of picks which would be woven if the loom were weaving every second of the time operated. As the warps are generally twelve hundred yards long when woven, the formula can be worked out with the exception of the three variables, PPI and the number of hours the weaver takes for the job, and PPM .

Simplifying:

$$\frac{1200 \times 36 \times PPI}{60 \times \text{hours to weave the job} \times PPM}$$

Each fabric woven has its standard number of picks per inch, so for any fabric, the formula can be worked out with the exception of the two variables below the line. For a fabric with fifty-four picks per inch the formula would then be

$$\frac{1200 \times 36 \times 54}{60 \times PPM \times \text{hours weaving}} \quad \text{or} \quad \frac{38880}{PPM \times \text{Days weaving}}$$

Rather than develop formulas for each kind of fabric in the weaving mill it will be of more interest now to turn to the application of the rating plan to specific weavers. We shall use the data which follows—namely, that three warps of cloth were finished in a given month by each of three weavers. The warps had been started some time previous to the month when they had been finished, but the data does not become available, until the warps have been completed. The data is given in tabular form for convenient reference.

Weaver	Loom No.	Fabric Woven	PPI	Length Woven	Days Weaving	PPM	Material In Fill.	Ends in Warp	Material In Warp	Harness	Loom
A	423	Flora	48	1200	40	120	½ spec.	1000	½ spec.	24	2
A	425	Jasper	54	1200	48	108	½ spec.	1100	reg.	16	2
A	426	Annette	54	1200	47	108	reg.	1000	reg.	12	2
B	267	Flora	48	1200	45	110	½ spec.	1000	½ spec.	24	2
B	268	Dean	60	600	27	105	½ spec.	1300	reg.	24	4
B	270	Annette	54	1200	48	108	reg.	1000	reg.	12	2
C	383	Dean	60	1200	50	120	½ spec.	1300	reg.	24	4
C	384	Jasper	54	1200	48	108	reg.	1000	reg.	12	2
C	387	Annette	54	1200	48	108	reg.	1000	reg.	12	2

Substituting the required figures in the formula developed on the previous page, the weaving efficiencies are found for all the jobs listed above. The more significant items and the efficiencies are listed below.

Weaver	Cloth	PPM	Efficiency
A	Flora	120	80%
B	Flora	110	78%
A	Jasper	108	83%
C	Jasper	108	80%
A	Annette	108	85%
B	Annette	108	83%
C	Annette	108	83%
B	Dean	105	85%
C	Dean	120	80%

Let us assume for the present that these instances are typical and representative of loom speeds and fabrics as well as individual weavers. It will then become clearer what is to be gained from this rating plan. By referring to the table, one notes that on the Flora cloth B is two points less rapid than A. He is also two points less efficient than A in weaving Annette cloth in a case where loom speeds are identical. There is agreement in the two records as to the relative slowness of B as compared with Weaver A.

Weavers B and C show the same speed in weaving Annette cloth on looms of identical speeds. C is three points slower than A in weaving Jasper cloth, each weaver having a loom with a speed of 108. This indicates that C and B are about the same on quantity rating. However, in weaving Dean cloth, C seems to be five points slower than B. The loom for C weaving Dean cloth was 120 PPM whereas B had the cloth on a loom running only 105 PPM. The inference is that Dean cloth, the finest of the three fabrics and having sixty picks per inch, does not run so well on fast looms.

Comparison of the ease of weaving various fabrics is readily made from records of this nature. Dean cloth of high pickage per inch and requiring four boxes gives difficulty on fast looms, but not on looms of moderate speed.

Flora cloth is not affected by loom speed although it is a slow weaving cloth, its slowness not being due to the number of boxes but to the special yarn in its warp and filling, and to the large number of harnesses used in its pattern. How much of the slowness in the Flora cloth is due to the kind of yarn in the warp and filling and how much is due to the numerous harnesses, or how much the slowness is augmented when the two factors are combined, must be determined by further experiments. However, it is just this type of record built into an experience table which is necessary in order to find the usual weaving time for each kind of fabric with reference to filling used, type of loom on which it is woven, or any other significant variable.

In any one season the weaving mill is not likely to make more than ten or fifteen different kinds of cloth, so that the proportion of records that can be used in direct comparison is large. Furthermore, from season to season a few new kinds of cloth are introduced, so the experience data is continually enlarged and made more useful in establishing the relative effects of each change in the variables.

There is not a burdensome amount of clerical work involved in the rating plan just demonstrated. There is only one warp per loom in six or eight weeks. The posting and calculating are done only about once in a week for a six loom weaver, with one extra entry when a new warp starts. A notation is also made each time a weaver makes an inferior cut of cloth. The clerical work is simplified after the efficiency formulas are prepared showing the total pickage in warps of each fabric. A master working schedule carries a record of the hours worked by the department each day, and makes it a simple matter to find how many weaving hours have been consumed on each warp. The weaving efficiency on a warp will be found by the record clerk by making two calculations; the picks per minute (loom speed) is multiplied by the hours weaving and that product is divided into the numerator of the formula previously developed. If there is no attendance

record card for each weaver, the individual production record card should have notations of absence of the weaver, so that proper deductions may be made for absence of the weaver unless the notation indicates that a substitute weaver was running the looms in the absence of the regular weaver.

Caution must be observed about relying too much upon any type of rating of weavers before having sufficient records to constitute a satisfactory table of experience. Evidently no weaver will attain one hundred percent efficiency. Delays do occur. We also notice that some fabrics by their nature weave more easily than do others. It is possible that in a given period one weaver may have warps or fabrics on which it is easy to secure a high efficiency. The Absolute rating in either case correctly states the weaver's production rating. What other weavers accomplish under corresponding conditions enables a better judgment as to the real efficiency of the weaver in question. So Relative rating is the type which naturally will soon be used, although the efficiency percentage was first started as an Absolute rating. Gradually there will be accumulated sufficient experience data to determine proper standards of efficiency on all fabrics.

These experience tables of weaving efficiencies are valuable records for several purposes. They are guides for setting piece rates accurately. They are useful in planning production schedules as the planning department can estimate when warps will run out, how much allowance is necessary for seconds, and how delivery promises can be met with greater precision. The records are also very useful in cost finding or cost allocation. The allowance for seconds is not only a time or quantity factor, but is a cost factor. Likewise the ease or rapidity with which a fabric weaves is a cost factor as it involves time—time for which a weaver must be paid wages and for which overhead costs are involved. These records become bases for standards which the production department should continually try to improve; and they shed light upon the various ef-

forts to improve either the quantity or the quality of production.

The rating of weavers has exemplified the principle previously set forth that eventually Standard rating as a type is sought in every rating plan. In the weaving operation the type of rating first introduced is that of absolute rating because it is easy to secure and tabulate the records which show how much weaving an operative is doing as compared with what he would do if he had no stops at all. Absolute efficiencies were compared with each other in a relative type of rating. A management wants the highest efficiency that is reasonably and regularly attainable, and so Standard rating is the type eventually used.

CHAPTER VII

DEVELOPMENT AND USE OF INDIVIDUAL PRODUCTION RECORDS

Since production rating is based on objective facts, the first concern is what reports are available from which to get the data needed to make the rating. When the introduction of a rating plan is contemplated, it is well to make a review of all the production records that are available from the department under consideration, and see if any of those reports will furnish all of the information pertinent to production rating. The next step is to make whatever alterations in the records are necessary so that while meeting the purpose for which they are designed, they will also supply information required for the rating study. It may be advisable sometimes to secure an entirely new report for the rating study, but this is generally inadvisable. It is more satisfactory if possible, to incorporate the information of the rating with regular current reports.

There are certain advantages in including on payroll records or summaries, the data required for rating purposes. The reports of the payroll department are checked for accuracy, they are always up to date, and they form a permanent file which is readily accessible. In some situations the data in payroll summaries may be incomplete or unsatisfactory for rating operatives, in which case it would be well to go back to the orginal sources for the information which the payroll summarizes. A report such as the following is useful in getting the information which the payroll department requires for paying winders on a piece rate basis.

It may be advisable to furnish operators with cards on which they can keep records of the jobs which they are doing. Such a card will serve a number of different purposes. The operator can keep track of assignments that she is handling, and she will have a feeling of satisfaction in filling up the card as rapidly as possible. It will serve as a notebook to which she can refer to check pays re-

WINDING REPORT

LOT NO.	COUNT	NUMBER OF BOBBINS TO CONE	SPINNER
WINDER'S NAME		CHECK NO.	MACH. No.
MACHINE DELAYS		OPERATOR'S DELAY	GROSS
NUMBER OF CONES	DEFECTIVE CONES	INSPECTED BY	TARE
DATE	WEIGHED BY		NET

ceived. One other important purpose is served by the card, namely, that whenever the operator is about ready for a new assignment she can take the card to the desk of the assignment clerk or the foreman, who can see what kind of work she has been having. This enables the foreman to make more satisfactory distribution of work. A sample of such card follows on page 92.

A sample form of recording data regarding a weaver's production is shown on page 93. A card on which the periodic ratings of a weaver may best be kept is shown on the next page thereafter. (See page 94.)

In collecting the information regarding all of the points which are to be considered in a production rating plan, it is desirable to summarize all data on one page. A working sheet which shows all this information might well give the factual information, and then list in columns the opinion ratings which the foremen have given to the respective winders. Space may be left for the rating which will be used on the permanent record, as this final rating may not always correspond to the foreman's opinion. When

WINDING

Operator _____ Check No. _____ Machine No. _____

DATE	YARN NO.	SPINNER	LOT NO.	TIME STARTED	TIME FINISHED	DEFECT-CONES	REMARKS

all of this information is on the working sheets it is well then for the Employment Manager or the person in charge of employee rating to confer with the foreman and superintendent, and agree on the final ratings that shall be given on each point.

The following items may be desirable on working sheets on which conferences may be held before final ratings are agreed upon. The person making the rating study should confer with employment and production executives after the executives have had time to study the working sheets.

1. Name of operators
2. Check Numbers of operators
3. Number of weeks in the average for each operator
4. The highest week's earnings for each operator
5. The average hourly or weekly earning for each operator.
6. The average hourly or weekly production for each operator
7. The average amount of waste, defective work, and other quality items, with reference to the amount of production of each operator
8. Quantity ratings, quality ratings, attendance record and length of service, as taken from records or objective measurements
9. Ratings of the operators as given by the foreman
10. Records if any, and ratings for conduct or any other personal factor
11. Remarks
12. Spaces or columns for final ratings.

WEAVER'S PRODUCTION RECORD

Name

Check No. | Mill | Section

LOOMS | SPEED

Absence: Excused | Un-Ex.

QUANTITY RECORD

Loom No.	Cuts in Warp	FABRIC	Picks per Inch	WEAVING TIME IN Date	IN Hour	OUT Date	OUT Hour	Hours	% Eff.	Standard. Eff.	Ratio to Stand.

IMPERFECT CLOTH

Cut No.	Cause	Cut No.	Cause	Cut No.	Cause	% Qual.	Adjusted Qual. Rating

WEAVER'S PERIODIC RATINGS			NAME			LOOMS					
			CHECK NO.	MILL	SECTION						
QUANTITY			QUALITY	CONDUCT	ATTENDANCE						REMARKS
PERIODS	WARPS	AVERAGE EFFIC. RATIO			TOTAL WORKING DAYS	ABSENCE				ATTEND. RATING PERCENT	
						EX.	UNEX	LATE	TOT'L		
JAN. TO JUNE 19											
JULY TO DEC. 19											
JAN. TO JUNE 19											
JULY TO DEC. 19											
JAN. TO JUNE 19											
JULY TO DEC. 19											
JAN. TO JUNE 19											
JULY TO DEC. 19											
JAN. TO JUNE 19											
JULY TO DEC. 19											
JAN. TO JUNE 19											

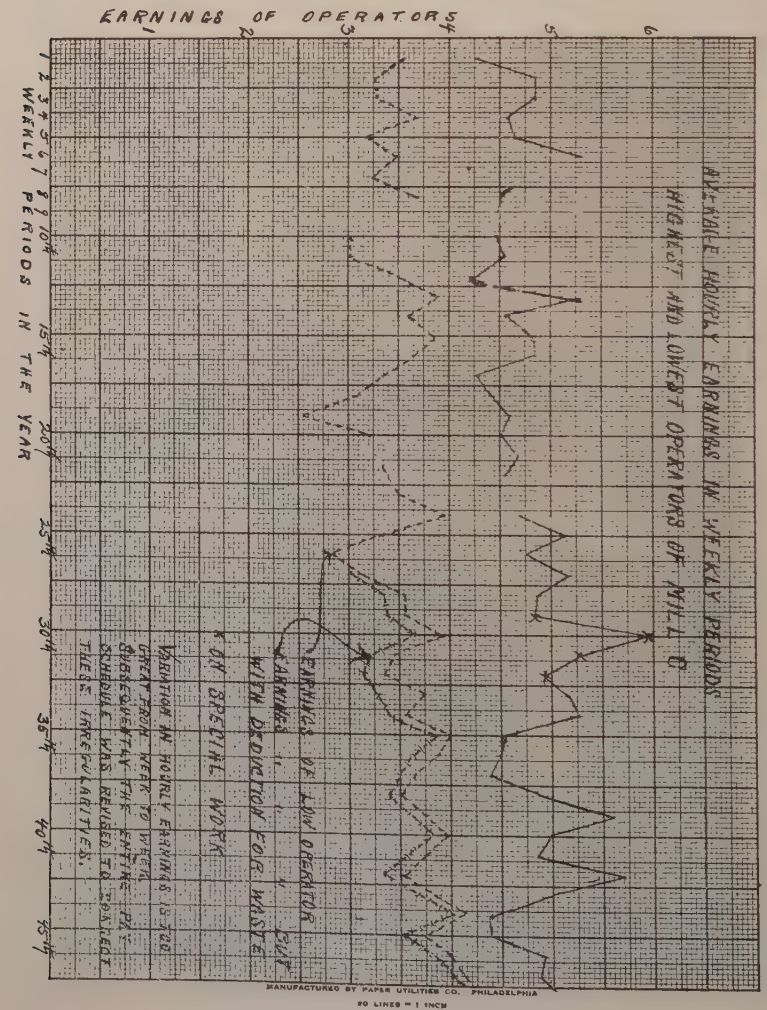
The information which is summarized on the working sheets will be of great value to the departmental executives if they choose to use it. The foreman and the superintendent are the ones who can best use the information, and therefore not only the permanent records, but all working plans and working sheets should be discussed with the foreman. So far as is reasonably convenient, the data should be made available for the foremen in whatever ways and at such times as best suit their purposes.

If personal record cards are kept, the information should be transferred to the personal record cards, as the information is valuable for the Employment office in considering lay-offs, rehires or transfers. A large manufacturing company in Massachusetts has been keeping personal production records in the employment office but transfers them to the production department as soon as the foremen take enough interest to request the records. It would seem good policy to list the ratings of the employees on the personal record card at least twice a year.

Sometimes it is much more satisfactory to make reports for the foremen and superintendents in graphic form. There are some companies which carry the production record of each employee week by week, extending a line graph to indicate the quantity. On the same chart may be a curve which shows the percentage of seconds or waste, i. e. quality of production. In case the quality line indicates amount rather than percentage, the quality line should also indicate amount, e. g. total of seconds or waste. If one line shows percentage, the other should also. The quality line may be used in either of two ways. It may indicate the amount left after deducting from the quantity production, the amount of waste or seconds. In such case, the quality curve will fall near the production curve and should be a broken line or some kind of a line other than the quantity line. (See graph on following page). The percent of loss on account of poor quality may be plotted from the base line. In this last case improvement in the efficiency of the operator would be shown when the quan-

tity line moved upward and the quality line swung downward. This arrangement is quite simple and is more helpful than the other diagrams in relating total losses to the company by reason of poor quality, to the particular amounts or percent of loss occasioned by each operator.

For certain reasons it may be desirable to state the quantity and quality of production in a single figure. In


EARNINGS OF OPERATORS
1
2
3
4
5
6
WEEKLY PERIODS IN THE YEAR
AVERAGE HOURLY EARNINGS IN WEEKLY PERIODS
HIGHEST AND LOWEST OPERATORS OF MILL C
EARNINGS OF LOW OPERATOR BUT WITH DEDUCTION FOR WASTE
& ON SPECIFIC WORK
VARIATION IN HOURLY EARNINGS IS DUE GREATLY FROM WEEK TO WEEK SUBSEQUENTLY THE ENTIRE PIECE SCHEDULE WAS REVISED TO CORRECT THESE IRREGULARITIES.
MANUFACTURED BY PAPER UTILITIES CO. PHILADELPHIA
20 LINES = 1 INCH

an efficiency percentage rating this would be done in the following manner: From the percentage of quantity of production which is attained by the operator, would be deducted the percentage which represents the waste, seconds, spoilage or other lack of perfect work. In case of rating in terms of earnings the figure representing quantity would have a deduction according to the lack of quality in the production turned out by the operator. Suppose that an operator has earned an average of 44 cents an hour for a six months period and she has waste amounting to five percent of her earnings, with no other lack of quality in her work. Five percent deducted from 44.0 cents would leave 41.8 cents as the single figure representing both quantity and quality. If, however, as in the case of cloth making, the weaving of a second occasions a loss three times as great as the loss in production of a piece of goods, then it is proper to deduct from the quantity figure three times the amount of seconds made. Thus if the production were forty pieces in a given period and one piece was a second, the net production may be reckoned at thirty-seven instead of thirty nine. If the production of forty pieces is considered as eighty percent efficient, the deduction for seconds on the basis just cited, would leave a singe figure of seventy-four percent when quantity and quality are combined.

It might be supposed that a single figure representing the average of all individual production ratings shows the departmental efficiency. The figure might show the average production corrected for poor quality of the piece workers, but it does not show the departmental production efficiency. The reason is that there are other workers in a department besides the piece workers, even in a so-called piece-rate department. A foreman may have so many day rate workers that the piece workers are greatly assisted thereby and make a creditable showing at the heavy expense of a big payroll for the day workers. Quality is often influenced seriously by the number of day workers and their efficiency. A departmental production

rating should reflect total results attained by all the operatives of the department. Thus the single figure for the department based on individual production rating of piece workers must not be confused with the proper production rating of the department.

A factual rating system of this kind necessitates considerable statistical work. It is perhaps inadvisable to curtail the clerical work which at first seems to be unnecessarily tedious and expensive. It is certainly advisable that the correlations should be worked out in order to insure the reliability of the records and the accuracy of the procedure. For example, since weight is the basis of pay, and there are differences in the weight of products of the department, it seems worth while to work out the correlation between the total poundage and total earnings to make sure that there is fair distribution of work among the operators.

There are certain comparisons or correlations to be profitably made after the ratings have been completed. It is quite helpful to compare the foreman's opinion ratings and those from factual findings on each of the phases, quantity and quality. The comparison will take note of and encourage the foremen's progress in grading and will also check errors in the statistical work of rating. It will review the findings in such a way as to elicit helpful criticism, and it may bring about some stimulating competition among the foremen. It is worth while to make comparison between the records of the same department in different periods. This will enable one to see the trend in production. A helpful comparison can also be made between similar departments.

The significance of the results in the use of such a rating system as has been outlined, will depend upon several factors. The significance is restricted in the first place by the extent and the reliability of the records which are available on which to base the ratings. As an example, the hours worked in one of the mills studied, were listed on the operator's card from the morning report of the

foreman of the department, and if the operator was there at the beginning of the day, she was listed for a full day's work even if she might have gone home at ten o'clock for personal reasons. The only occasions when the total hours for the day were changed were when special notice was given of an operator's change of hours, or when the department as a whole closed before regular closing hours. In this latter case, all operators were listed as working short time. The interpretation of the results is limited also by the extent to which standardization has been carried out. Mention only needs to be made here as this factor has been discussed in other chapters.

CHAPTER VIII

SUMMARY

Individual productivity is a basic factor in economic development. Industry in the past was so intent upon the product that it has been slow to apply scientific management to the human factor. Since changes in labor personnel are constantly being made, the adaptation and improvement of the laborer and the job necessitates careful and wise handling if the best results are to be obtained. Employee production rating may assist materially in the development of working methods and in the control of the labor personnel with resultant increases in productivity.

The old method was to rate employees on the basis of the foreman's opinion. When measurements are used in determining the quantity of individual productive output, it is discovered that the foreman's opinion is right in about one-half of the cases. There is nearly as much discrepancy between fact and fancy with reference to rating quality of production of employees. Without other aids than impressions, the foreman fails to identify the poorest operators in the department or he over-rates them all. In doing so, he overlooks a strategic opportunity to strengthen the weak section in labor personnel, and thereby increase output per man hour.

Much is gained by the use of scientific method in rating workers. Fairer treatment is in store for employees when measurements are made of their respective services. In the average textile mill, an increase of 10% in production per machine hour with labor paid for at a constant rate per piece, would mean a possible saving of over 5% in total costs of labor and overhead. The consuming public benefits by the greater ease and rapidity with which its wants are supplied. Besides these immediate economic advantages, there are demands from various branches of industrial investigation for critical and discriminating data pertaining to employee output. Psychological research,

training, promotion systems, bonus plans, personnel and case work, and many other management devices are needing criteria, evidence, measures, concrete figures. So there is urgency for the management to assume the task and improve the technique of individual production rating.

The three TYPES of production rating may be termed Absolute, Relative, and Standard. Absolute Rating compares the production of an individual with what would be perfect production. It shows the total lost time from all causes, the lost time being stated in a lump sum or in percentage, without indicating what would be the corrrect or reasonable amount of delay time. Under Relative Rating, the actual accomplishment of each operator is compared with that of every other operator working under similar conditions. As in other types of rating, analysis of all conditions and variables involved in the job is necessary in order to give proper credit for productive performance. This type of rating does not attempt to state what should be the average production for each operator. Standard Rating attempts to state how nearly the operator should attain perfect performance. Comparison is made between the actual production and that mark which has been set as the reasonable or proper performance to be expected. Complete standardization would make due allowance for every variable. Standard rating is the ultimate goal of any rating project.

The main steps of the METHOD to be followed in the introduction and development of rating have been exemplified in this research. The first step is to make an analysis of the job—an analysis that will be far more than a brief description. The job description should be expanded to set forth the essential features in the standard procedure followed. As the job is studied, variables will be found. Analysis of all variables is relevant whether of materials, machinery, processing, interruptions or working conditions. The next step is to standardize so far as practicable, the variables themselves or the allowances for the variables. All forms of available reports are to be

examined with a view of selecting one or more, the contents of which will furnish a basis for rating individual workers. To serve well for rating employees, the reports must be accurate, reliable and regular. If no current report carries sufficient and satisfactory information, one must be amended to suit. The selection and application of a rating plan can then be made. The next step is to summarize the data and present the findings in a suitable way to the employment and production executives. After revisions or additions made in such conferences, permanent records should be compiled. Every step in the rating work should be checked for accuracy and validity of findings.

There are practical LIMITATIONS in the usefulness of individual production rating. In the first place the validity of the ratings may be vitiated by a lack of accurate and complete records, or by careless handling of the study. Production rating does not in itself increase individual productivity, nor does it cover processing of materials in such a way as will necessarily stimulate the introduction of technical short cuts or improvements.

There are certain PURPOSES and RESULTS to the accomplishment of which the study of individual production rating contributes. It tends to establish a systematic analysis of all the conditions and variables attendant in the production so studied. The study relates output to conditions in such a tangible way that cost analysis is provided with helpful information. The rating study supplies pertinent facts for guidance in lay-off, rehire, and promotion. The data secured in production rating are of special value in adjusting pay schedules. The study of individual productive output gathers and classifies facts in which psychological testing may find useful criteria and in which personnel case workers may discover significant results. Not the least purpose which this rating may serve is the encouragement of standardization and the extension of executive control.

Allowing for qualifications or limitations, there are

certain generalizations which may be made from individual production rating. It will show to a dependable degree of accuracy the various amounts and qualities of productive output by the different operators. The average production per operator may be determined, and these averages may be watched to measure the effect of changes in materials, equipment, processing, hours, working conditions, wage incentives, or any other variables in the job. The effect of a change in training or supervising methods may also be observed in the individual production figures. However, it is quite patent that in industry it is very difficult to keep constant all of the variables but one, in order that the effects of changes in that one variable may be observed. Actual situations are not so simple; and yet in all instances the measurements thus obtained are far better than mere guesses in determining the results of particular changes in manufacturing or in management methods.

The statistical grouping of operators have significance. It may indicate the advisability of securing many or few learners. For example, if there are only a few poor operators in the department, it would be unwise to secure a large group of learners. If there are many poor operators, with medium length of service, the labor market easy and steady production ahead for the department, it would be good policy to hire some learners. Training and pressure should then thin the ranks of the poor class of operators either by elevation or elimination.

In order that individual production rating may be most useful, it is necessary to enlist and cultivate the interest and cooperation of the employment department, superintendent, foreman and employees. However fair the foreman's attitude, unless aided by objective measurements made in a systematic manner such as it has been our purpose to describe, his opinion as to quantity and quality of production of each employee is not sufficiently accurate to guide him most effectively in making opportune improvements in labor efficiency.

By the method here developed and followed, fairly reliable records have been secured at comparatively small cost and effort. On the basis of these records, it has been possible to undertake and carry out changes of considerable practical value. This technique will advantageously assist both personnel and production executives in their endeavors to increase individual productivity.

APPENDIX A

GLOSSARY

BOBBIN This is a piece of wood around which yarn is wound. A bobbin has a hole in the center of the base through which the spindle passes. A bobbin is shaped like a very long slender spool with a flare on only one end.

CONE A cone is either the paper form on which the yarn is wound or it is the package of yarn.

CONE ARBOR is the part of the winding frame which holds the paper cones in place.

COUNT indicates the size of yarn. Count 1 is yarn of a fineness requiring one pound to make a length 840 yards; a pound of count 2 would make 1680 yards, of count 3 would make three times 840 yards, etc. 24/2 is the way to indicate count 24 of 2-ply yarn. In weight, a given length of 24/2 is equivalent to the same length of 12/1. Generally knitting yarns are written 30/2 whereas the same yarn for weaving, i. e. carded yarn, is written 2/30.

DOFFING means taking off the finished cones and putting on new ones preparatory to winding another set.

END An end in textile language means either one yarn or thread, or it means the extremity of a piece of yarn. Since textile operations with yarn often involve finding the proper end of yarn and connecting it with another, end has come to mean yarn.

FRICTION ROLLER on a winding machine is a smooth cylindrical roller which, revolving at a high rate of speed, turns the cone by friction when the cone is lowered to contact with it.

KNIVES as used on a winding machine are two pieces of metal with smooth, level surfaces, which are adjusted at certain distances apart, face to face. Yarn must pass through the slit between these pieces of metal. The slit is only ten to twenty-five thousandths of an inch wide, so the knives will break out thick places or knots in the yarn.

PLY indicates the number of strands which compose the yarn. The fibres of each strand twisted in one direction and the strands or plies twisted together in the opposite direction. Two-ply is composed of two strands of yarn twisted together, three-ply of three strands, etc.

SECONDS is a term used to mean products inferior to the usual or first grade.

SPINNING may be used in the sense of spinner, i. e. the manufacturer who produces the yarn.

SLACK TWIST Yarn in which the strands of yarn are twisted together loosely.

SLUBS are portions of the yarn which appear thicker than the rest of the yarn due to the fibres not having been drawn out parallel and twisted as evenly as the perfect yarn.

SLUB CATCHER This is a device to catch and break the yarn where slubs occur.

STAPLE refers to the small fibres which are drawn parallel and twisted together to form yarn.

TENSION BASE This is an arrangement which the yarn passes through in winding so that the yarn will be wound with the same firmness or tension in all portions of the package.

APPENDIX B

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APPENDIX C

INSTRUCTIONS FOR STANDARD PROCEDURE IN WINDING

I. Start first row of bobbins winding on the machine.

II. Mark time, number of rows ,whether gassed or spooled etc., on card, and record similar information on the Coning tickets.

a. Tie an end as soon as it breaks, and start it winding immediately. Tie on new bobbin as soon as a bobbin finishes winding.

III. Lay out the other rows of bobbins.

IV. Stamp cones just completed.

V. Mark stamps for cones being built on the machine.

VI. Place an empty paper cone above each cone arbor.

VII. Mark time on the card as soon as the first cone of the set has finished winding.

VIII. Take card to foreman's desk, and write your number in the column for a new assignment.

IX. Doff;—as each cone is completed, remove it from the cone arbor and place it on the shelf.

X. a. See that the machine is in proper condition, and put an empty paper cone on the cone arbor.

b. If possible, lay out the new set of bobbins while the last row of the old set is being wound onto the cones.

XI. a. In case another run is to be made on the same knife adjustment:—As each cone is completed, start a new cone winding. (Note—It is more important to keep old cones running than to start new cones, therefore keep old cones winding before starting new ones.)

b. In case knives are to be adjusted before the new run:—Make ready for new run as much as possible. When last cones are nearly completed, call the mechanic. Start the new cones winding as soon as possible.

I. START FIRST ROW WINDING ON THE MACHINE

1. Take several bobbins from the truck and place all but one under the arm or on the shelf.
2. Slide that one bobbin down onto the spindle with right hand, while end of yarn is being pulled off with left hand, and up to the tension.
3. With right hand catch yarn from bobbin about three inches below tension, and draw the yarn parallel with the knife, while left hand draws yarn on thru the tension and under the drop wire.
4. a. Pass the yarn over the cone with the left hand, and pull the end of yarn slightly to the right.
   b. With right hand push in the ratchet handle which lowers the cone to the roller.
5. With right hand raise the rocker-stop-motion.

JOBS TO BE DONE WHILE ENDS ARE RUNNING

1. Lay out the balance of the bobbins around each bobbin spindle.
2. Place stamps in set of cones just completed.
3. Remove empty bobbins from bin.
4. Wipe lint and dust from machine.
5. Mark the machine number in stamps given to you by the cone inspector.
6. Place empty cones above each cone arbor.
7. Cut off roller laps.
   Hold knife against yarn wound on the shaft. Do not hold the knife against the parts of shafting that rest in bearing.

A. TYING WEAVER'S KNOT AT CONING MACHINE

1. a. With the right hand catch end of yarn from bobbin and draw it thru knife and under the drop wire.
   b. At the same time with the left hand, catch the end of yarn on cone and pass the end to the right hand.
2. Wrap both ends around the right hand, (preferably once and in any case not more than three times.)
3. With second and third fingers of left hand catch the end from bobbin and draw it slightly to the left; at the same time with the left thumb push the thread from the cone to the right. Hold the ends thus crossed between the thumb and first finger of left hand.
4. Slide right thumb and first finger along yarn until nails of right and left thumbs are back to back.
5. Break the ends off evenly by pulling downward and inward with right hand.
6. Catch yarn from bobbin with right hand, swing it around the left thumb, holding the yarn against the side of the left thumb with the second finger of that hand. Draw the yarn around the left thumb and between the opening formed by the crossed ends first passing back of the end pointing out to the left.
7. a. With the right thumb, push the end pointing to the right, down onto the left index finger, raising the left thumb so that the end passes under it.

b. Place the left thumb back on the end just passed under it.

8. With the right hand draw the yarn taut.

9. a. With the right hand push in the ratchet handle, which lowers the cone to the rollers.

b. With the left hand guide the yarn to wind onto the center of the cone and keeping a bit of tension on the yarn until all the slack is taken up.

10. With the left hand raise the rocker-stop-motion, which starts the guide distributing the yarn over the cone.

APPENDIX D

WINDERS' PRODUCTION RECORDS

MILL C, LAST HALF 1924

Check No.	Weeks of Work in Average	Hourly Earnings %	Foreman's Opinion				Attendance			Length of Service	
			Quantity	Quality	Conduct	Attendance	Days Excused Absence	Days Unexcused Absence	Times Late	Yrs.	Mos.
269	25	115	A	A	A	A				4	3
283	24	113	A	A	A	A	7			2	11
267	25	109	B	A	A	A					8
275	9	109	B	A	A	B	½			2	6
263	25	108	A	A	A	A	6½			2	7
289	25	108	A	A	A	A	5½			1	9
276	24	108	A	B	B	B	12		3	2	2
238	23	108	A	A	A	A	2½			1	2
233	25	107	B	B	B	B	3½			4	8
240	25	106	B	B	A	B	6			4	10
278	25	106	B	A	A	B	4½		7	2	3
241	25	105	A	A	A	A				2	2
277	15	105	A	A	A	A	12½			4	4
256	25	105	B	A	A	A	7			2	7
284	25	105	B	A	A	A	4			2	7
292	16	105	B	A	A	A	1½				9
253	24	104	A	B	A	B		9½		5	10
270	25	104	B	A	A	A	2			4	8
246	24	104	B	A	A	B	11			1	9
266	25	104	B	A	A	B	5		4	1	6
248	25	103	B	A	A	C	7		2	2	8
281	25	103	B	B	A	A	½			2	7
285	25	102	B	A	A	A	7½			1	11
265	25	102	B	A	A	A	2			3	5
232	25	102	B	A	A	B	2½			2	8
262	25	101	B	A	A	B	3½		1	3	
251	25	101	B	A	A	A	5½			5	
296	14	101	B	B	A	C	2½			2	1
235	25	101	A	A	A	A	3½			7	10

Check No.	Weeks of Work in Average	Hourly Earnings %	Foreman's Opinion				Attendance			Length of Service	
			Quantity	Quality	Conduct	Attendance	Days Excused Absence	Days Unexcused Absence	Times Late	Yrs.	Mos.
280	12	101	B	B	A	B	5½			1	5
271	25	100	B	A	A	B	6		1	1	9
273	25	100	B	A	A	A				2	2
252	25	100	B	B	A	A	½			1	4
264	25	100	8	A	A	B	½		1	3	5
290	22	99	B	B	A	B	15½			3	8
234	25	98	B	B	A	A	5½			1	6
272	25	98	B	A	A	B	1			2	6
279	25	98	B	A	A	A	3½			2	11
282	3	97	B	B	B	C	9½			1	3
254	17	97	B	B	A	A	14		2	2	8
286	13	97	B	A	A	A					3
245	25	96	B	A	A	A	2½				8
243	23	96	B	A	A	C	22		1	1	8
236	25	96	B	B	A	B	9		1	3	5
258	25	95	B	B	A	B	5½		3	2	3
237	21	95	B	B	A	B	25				10
247	8	94	A	A	A	C	6	13	2	3	3
287	8	90	B	A	A	A	2				3
247	9	90	D	B	A	A	½				9
268	25	90	B	B	A	A	½			2	11
239	23	89	B	B	A	A	1				10
274	14	88	B	A	A	A	2½				5
249	25	87	B	B	A	B	2	1		1	7
291	4	86	B	A	A	B	3	4			3
231	25	82	B	A	A	B	3½			1	7
250	16	81	B	A	A	A			3		5

APPENDIX D
INDIVIDUAL PRODUCTION RECORDS—MILL C
Last Half, 1927

Check No.	No. weeks in Aver.	% of Aver. Quantity	Waste in % of Earnings	Aver. No. Bad Bobbins
49	4	85.		
47	25	91.4	8.2	.08
33	23	92.7	6.4	.30
57	18	92.9	6.8	.28
53	6	94.5	2.7	7.00
50	26	95.7	5.1	.50
59	18	96.	5.4	.61
46	4	96.2	3.0	9.75
79	26	96.2	4.2	.00
64	26	96.8	3.4	1.32
74	26	97.3	4.3	.88
35	26	97.5	3.9	1.07
32	26	98.3	3.3	1.43
54	26	98.8	3.9	1.11
34	14	99.	4.4	1.50
40	26	99.	4.7	.69
41	26	99.7	3.7	1.23
82	16	100.3	5.0	.88
44	7	100.5	4.5	2.14
58	26	100.9	7.4	.15
87	25	100.9	4.0	.80
56	23	100.9	6.4	.35
85	26	101.	1.7	1.65
69	26	101.2	4.5	.54
89	23	101.2	2.8	1.78
36	22	101.2	4.7	.80
60	26	101.6	3.9	1.15
62	26	101.6	5.9	.34
71	26	101.8	7.8	1.54
48	25	101.8	3.8	1.24
52	26	102.2	7.5	.12
73	26	102.5	3.3	1.47
51	26	102.5	9.1	.04
84	26	102.9	3.3	1.39
38	26	103.1	4.3	.84
55	26	103.3	3.4	1.31
45	26	103.5	4.8	.76
81	26	103.6	3.9	1.04
43	26	103.8	6.5	.23
88	24	104.	3.9	1.08
37	16	104.4	4.9	.94
39	25	105.3	4.1	.96
61	26	105.3	5.5	.38
66	26	106.1	3.5	1.27
83	26	106.2	5.3	.46

APPENDIX D
WINDERS' PRODUCTION RECORDS, MILL B
July to December, 1924

Check No.	Weeks in Average	% Hourly Av. Wage	Quantity Production Ranking	Foreman's Opinion				Length of Service	
				Quantity	Quality	Conduct	Attendance	Yrs.	Mos.
)36	24	113	A	A	A	A	A	4	1
)98	25	113	A	A	A	A	A	4	
)72	19	111	A	A	A	A	A	2	
934	25	110	A	A	A	A	A	2	8
082	25	110	A	A	A	A	A	4	7
)10	25	110	A	A	A	A	A	4	7
968	25	110	A	A	A	A	A	3	
)55	25	110	A	A	A	A	A	3	9
)53	25	109	A	A	A	A	A	2	
)19	25	109	A	A	A	A	A	6	6
)75	25	109	A	A	A	A	A	3	
094	25	109	A	A	A	A	A	2	1
)91	25	108	A	A	A	A	A	4	
921	24	108	A	B	A	A	A	2	
)73	25	107	A	A	A	A	A	3	1
057	25	107	A	A	A	A	A	3	
)64	6	107	A	A	A	A	A	3	
967	24	107	A	A	A	A	A	2	2
)52	25	107	A	A	A	A	A	7	2
086	25	107	A	A	A	A	A	2	2
)28	24	107	A	B	A	A	A	1	10
960	25	107	A	A	B	B	A	3	
)41	24	107	A	A	A	A	A	10	
039	14	107	A	A	A	A	A	3	2
)40	9	107	A	A	A	A	A	2	
61	25	107	A	B	B	A	A	2	10
)38	25	107	A	A	A	A	A	2	
)29	21	106	A	A	A	A	A	2	1
)13	25	106	A	B	A	A	B	2	
)95	16	106	A	A	A	A	A	3	
027	25	106	B	A	A	A	A	5	
)84	25	105	B	B	A	A	A	3	
)40	24	105	B	A	A	A	A	2	
)24	17	105	B	B	A	A	A	2	6
)76	22	105	B	A	A	A	A	2	
056	25	105	B	A	A	A	A	3	
)25	24	105	B	A	A	A	A	1	9
)46	25	105	B	A	A	A	A	3	2
909	25	105	B	A	A	A	A	2	
016	24	105	B	A	A	A	A	3	
)21	25	105	B	A	A	A	A	6	2
)55	25	104	B	A	A	A	A	3	
959	25	104	B	B	B	A	A	7	

Check No.	Weeks in Average	% Hourly Av. Wage	Quantity Production Ranking	Foreman's Opinion				Length of Service	
				Quantity	Quality	Conduct	Attendance	Yrs.	Mos.
937	25	104	B	B	A	A	A	3	3
066	25	104	B	A	A	A	A	4	
031	25	104	B	A	A	A	A	2	4
971	22	104	B	B	A	A	A	3	
997	14	104	B	B	A	A	A	2	2
981	23	103	B	B	A	A	B	1	9
991	25	103	B	B	A	A	A	10	
965	25	103	B	A	A	A	A	3	
932	25	103	B	A	A	A	A		9
996	16	103	B	B	A	A	A	2	
081	25	103	B	A	A	A	A	1	6
979	25	103	B	B	A	A	A	3	
074	25	103	B	A	A	A	A	1	6
054	25	103	B	A	A	A	A	3	
970	25	103	B	B	A	A	A	5	7
980	25	102	B	B	A	A	A	3	
982	20	102	B	B	A	A	A	7	
987	25	102	B	A	A	A	A	3	
028	24	102	B	A	A	A	A	2	
941	25	102	B	A	A	A	A	4	3
908	25	102	B	B	A	A	A	5	2
914	25	102	B	A	A	A	A	3	3
026	25	102	B	A	A	A	A	2	
969	25	102	B	B	A	A	A	3	7
919	25	102	B	A	A	A	A	3	
051	25	101	B	A	A	A	A	3	
093	24	101	B	B	A	A	A	6	
951	25	101	B	B	B	A	A	3	
052	25	101	B	A	A	A	B	2	
037	25	101	B	A	A	A	A	3	11
045	25	101	B	A	A	A	A	2	8
929	25	101	B	B	A	A	A	4	
005	24	101	B	A	A	A	A	3	
926	25	101	B	B	A	A	A	1	7
007	25	101	B	A	A	A	A	1	7
985	25	101	B	B	B	A	A	5	9
918	25	101	B	B	A	A	A	4	
939	25	100	B	B	A	A	A	3	
936	17	100	B	B	B	A	A	4	
024	25	100	B	A	A	A	B	3	
097	25	100	B	B	A	A	A	8	2
011	25	100	B	A	A	A	A	3	4
087	22	100	B	B	A	A	A	2	8
956	25	100	B	B	B	B	B	3	
947	23	100	B	B	B	A	B	2	7
975	25	100	B	B	A	A	B	6	

Check No.	Weeks in Average	% Hourly Av. Wage	Quantity Production Ranking	Foreman's Opinion				Length of Service	
				Quantity	Quality	Conduct	Attendance	Yrs.	Mos.
068	17	99	B	B	A	A	A	3	
062	24	99	B	B	A	A	A	2	
060	25	99	B	A	A	A	A	2	1
912	25	99	B	A	A	A	A	3	
090	25	99	B	A	A	A	A	3	
003	25	99	B	A	A	A	A	3	
945	25	99	B	B	B	A	A	3	
070	25	99	B	A	A	A	A	3	
058	25	99	B	A	A	A	A	3	
061	25	99	B	A	A	A	A	2	3
069	25	99	B	A	A	A	A	2	3
992	23	99	B	B	A	A	A	2	
916	24	98	B	B	A	A	A	3	
053	25	98	B	A	A	A			
092	10	98	B	B	A	A	A	2	8
017	25	98	B	A	A	A	B	4	
048	25	98	B	A	A	A	A	3	
047	25	98	B	A	A	A	A	2	
917	25	98	B	B	A	A	A	1	8
015	22	98	B	A	A	B	A	2	7
920	25	98	B	B	A	A	B	6	7
943	21	98	B	A	A	A	A	2	7
077	14	97	B	B	A	A	A	5	
994	25	97	B	B	B	A	A	1	3
096	23	97	B	A	A	A	A	10	
008	25	97	B	A	A	A	A	2	10
004	24	97	C	B	A	A	A	3	
802	4	97	C	A	A	A	A	4	
042	25	97	C	B	A	A	A		2
915	25	97	C	A	A	A	A	3	
030	18	97	C	A	A	A	A	2	3
948	25	96	C	B	A	A	A	2	9
973	25	96	C	A	A	A	A	3	
958	25	96	C	B	A	A	A	2	3
986	25	96	C	B	B	A	A	2	
034	16	96	C	A	A	A	A	2	
977	25	96	C	B	A	A	B	4	9
966	25	96	C	B	B	A	B	2	5
025	25	95	C	A	A	A	A	10	
999	25	95	C	A	A	A	A	3	2
085	25	95	C	A	A	A	A	2	3
014	25	95	C	A	A	A	A	2	7
927	25	95	C	B	A	A	A	4	2
998	25	95	C	B	B	A	A	2	
006	6	94	C	A	A	A	A	1	10
013	21	93	C	A	A	A	B	2	2

Check No.	Weeks in Average	% Hourly Av. Wage	Quantity Production Ranking	Foreman's Opinion				Length of Service	
				Quantity	Quality	Conduct	Attendance	Yrs.	Mos.
009	25	92	C	A	A	A	A	2	9
032	25	92	C	A	A	A	A	10	2
964	25	92	C	B	A	A	A	2	
942	25	91	C	B	B	A	A	13	
018	20	91	C	B	A	A	B	1	6
099	25	91	C	B	A	B	A	3	2
963	25	90	C	B	A	A	A	7	6
059	25	90	C	B	B	A	A	3	2
080	13	90	C	B	A	A	A		5
933	24	89	C	B	A	A	A	1	9
983	25	89	C	B	A	A	A	2	
088	10	89	C	B	A	A	A	2	2
990	25	88	C	B	A	A	B	1	6
002	16	86	C	B	A	A	A	2	9
067	25	85	C	B	B	A	B	3	3
083	25	85	C	B	A	A	A	3	
946	7	85	D	B	A	A	A	3	
001	25	82	D	B	B	A	A	3	
050	24	81	D	A	A	A	B	1	7
063	10	81	D	B	A	A	A	2	
076	21	79	D	B	B	A	B	2	

APPENDIX D

INDIVIDUAL PRODUCTION RECORDS

Mill A, January to June, 1927

Check No.	Weeks in Average	Quantity Rating	Value of Waste in % of earnings	Defective bobbins discovered average per week
374	10	88	4.5	.6
414	24	90	3.6	1.6
389	5	91	4.2	2.0
407	25	92	3.1	2.4
375	21	92	4.0	.8
371	20	93	3.7	1.7
350	13	93	3.3	4.1
459	25	94	3.9	.9
351	16	95	3.6	2.3
424	5	96	5.2	.6
463	26	96	3.2	2.1
379	25	96	3.9	1.6
355	26	96	3.5	1.8
454	12	96	5.2	.3
383	6	96	5.3	.3
356	17	97	4.4	.4
439	25	97	4.2	.4
385	26	98	3.9	.9
372	26	98	3.9	.9
359	26	98	3.8	1.2
399	26	98	3.5	1.7
365	26	98	3.8	1.2
460	26	98	3.4	1.8
358	26	99	3.5	1.5
409	26	99	3.0	2.5
397	25	99	3.7	1.4
418	26	99	3.3	2.0
413	19	99	3.0	3.3
373	25	99	4.1	.6
405	26	99	4.4	.3
465	26	99	4.1	.5
427	25	100	3.9	1.0
366	25	100	4.3	.4
378	25	100	3.7	1.3
370	26	100	3.1	2.4
364	16	100	4.0	1.2
398	26	100	3.2	2.2
384	17	100	4.2	.8
400	26	101	3.2	2.2
468	25	101	4.0	.7
443	26	101	3.2	2.2
387	26	101	4.0	.7

Check No.	Weeks in Average	Quantity Rating	Value of Waste in % of earnings	Defective bobbins discovered average per week
374	11	101	2.6	6.3
380	26	102	3.3	2.0
403	26	102	5.0	.2
415	26	102	3.3	1.9
395	24	102	4.0	.8
456	22	103	8.9	.5
392	22	103	3.8	1.2
421	26	103	4.0	0.0
436	24	103	3.8	1.2
416	23	103	3.5	1.9
354	22	103	3.0	2.8
361	26	103	3.7	1.6
438	25	104	3.0	2.6
473	20	104	3.2	2.9
431	26	104	3.9	1.2
353	14	105	2.6	4.9
455	26	105	3.7	1.4
401	26	105	4.2	.5
417	26	105	3.4	1.9
406	26	105	3.7	1.3
382	23	105	3.5	2.0
377	22	106	4.0	2.0
368	22	107	2.8	3.0
376	26	107	3.0	2.5
386	24	107	3.9	1.1
474	26	107	3.3	2.1
404	24	108	3.6	1.9
396	26	108	3.3	2.2

Note the grading up of winders into a closer range of uniformly good operators in this first half of 1927 as compared with the second half of 1924 when the rating project began. The average earnings of a 100% operator in the latter period was 25.6% higher than that of the 100% operator of the former period.

APPENDIX D

COMPARISON OF RATINGS OF OPERATORS

Earnings per hour in percent of Average	MILL A		MILL B		MILL C		MILL D		TOTALS	
	Second half 1924	Second half 1927	Second half 1924	Second half 1927	Second half 1924	Second half 1927	First Half 1925	First Half 1927	First period	Second period
76							1		1	
77										
78								1		1
79	1		1						2	
80										
81			2		1		2		5	
82	1		1		1		1		4	
83							1		1	
84							1		1	
85			3	1		1			3	2
86			1		1				2	
87		1		1	1				1	2
88			1	1	1		4		6	1
89		1	3	2	1		3	1	7	4
90	4		3	1	3		3	1	13	2
91	3	1	3	4		1		1	6	7
92	1	2	3	2			3	1	7	5
93	2	2	1	3		2	2	1	7	8
94	3	2	1	3	1	1	4	3	9	9
95	7	4	6	5	2		1	3	16	12
96	7	4	7	7	3	4	1	2	18	17
97	7	4	9	11	3	3	3	3	22	21
98	10	10	10	10	3	1	3	4	26	25
99	8	7	12	14	1	3	6	2	27	26
100	10	7	9	14	4	3	7	8	30	32
101	12	5	12	13	5	7	4	9	33	34
102	5	4	9	10	3	7	6	5	23	26
103	6	3	10	13	2	4	8	6	26	26
104	7	5	7	8	4	4	2	5	24	22
105	7	6	10	6	5	2	3	3	25	17
106	7	5	4	5	2	2	6	3	19	15
107	7	5	13	4	1		5	2	26	11
108	2	2	2	5	4			2	8	9
109	1		4	2	2		4		9	2
110	2		5	3			4		11	3
111	1		1				3	1	5	1
112				1			1		1	1
113			2		1		1		4	
114							2		2	
115					1				1	
116							2		2	
Totals	121	80	156	149	56	45	97	67	430	341

The grading up of winders into uniformly good operaters is apparent. In ranges 96 to 105 inclusive are found only 59% of all operators in the first period; the same range covers 72% of all operators in the latter period. This grading up was accomplished in spite of speeding up machines and increasing the number of spindles per operator,—factors which ordinarily make an even greater spread in the range of operators. Altho wage rates adjustments were made for the purpose of offseting the change in working conditions, significant increases in average earnings were made in all the mills. Operators in Mill A made an average increase in earnings of 20%, in Mill B of 31%, in Mill C 30% and in Mill D 28%.

APPENDIX E

MEMORANDUM—PERSONAL RECORDS AND EMPLOYEE RATING.

To all Foremen:—

We have on Transfer and Separation Blanks the form:

Date _____

Reported by _____

Quantity _____

Conduct _____

Quality _____

Attendance _____

_____

The marks we prefer to have used are: A, B, C, or D. A indicates first class, B medium and C is third class. D would indicate undesirable such as we would not care to re-employ.

The term **Quantity** refers to the amount of production which the employee usually turns out. One who accomplishes a very large amount of work will be marked A, whereas a person who just barely does enough will be marked C.

Quality refers to the neatness and accuracy of the employee in his or her work. Other things being equal, the most skilled workman would be marked A, but even a very skilled workman might be listed as B or C if indifferent or careless about the quality of his work.

Conduct refers to the way the employee gets along with his foreman and fellow employees, and to dependability when the supervisor is out of sight.

Attendance is to apply to absences, tardiness and promptness in responding to overtime needs.

The blank line at the bottom is for any special characteristics which should be noted. For example, an exceptionally good teacher should be listed "Teaching A."

Please see that all the transfer and separation forms are completely filled in.

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